Problems of the Rhone Delta.

By R. D. OLDHAM, F.R.S.

I.

IT has long been known that the delta of the Rhone has undergone great changes since the close of the period of Roman empire. The changes are attested by historical records, but the evidence is contradictory; in part it seems to indicate a rapid advance of the sea face of the delta during the Middle Ages, yet there are mentions of places and dry land almost up to the present limit, and there is clear proof that places close to the existing coast-line were dry land and inhabited during the Roman period. These contradictions gave rise to a large volume of discussion, at times very controversial, by archæologists, geographers, and geologists during the last century, but the result was inconclusive, for the key to the solution had not been found. Work done since the beginning of the present century has thrown a new light on the problem, and especially a geological study by M. G. Denizot, which was published in 1924 by the Société Géologique de France, has made a re-examination of the question possible, and led to the possibility of drawing an outline of the changes which have taken place since the dawn of our era.

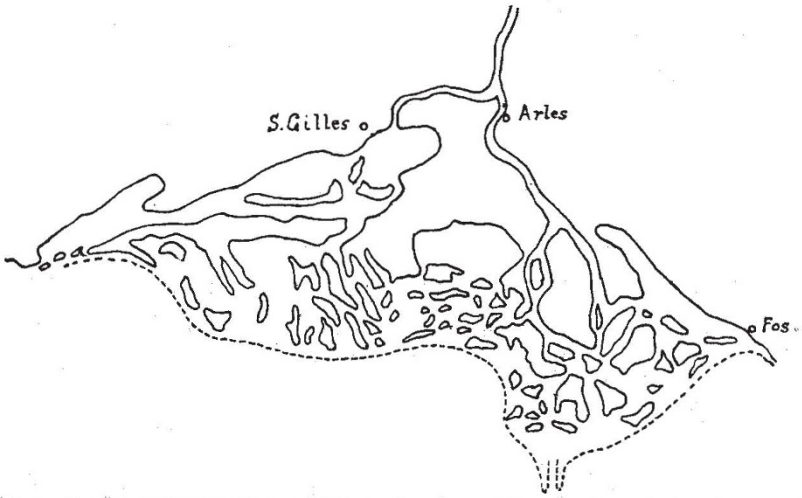

FIG. 1.—The Rhone delta about the end of the tenth century. This sketch does not attempt accuracy of detail; it is purely diagrammatic and intended to represent the general type of topography which resulted from the subsidence in the Dark Ages. The outline of the waterways must have been more intricate than can be restored, or represented, on a small-scale map. The broken line represents, approximately, the outline of the delta in Roman times.

On a map of the region, the river Rhone is seen to divide just above the city of Arles into two branches, of which the western flows past St. Gilles and, curving to the southwards, enters the Mediterranean just west of the village and shrine of Saintes Maries, while the main stream, which carries four-fifths of the water, flows southwards to the sea, keeping near the eastern margin of the delta proper. Between these two streams is a triangular tract of country, known as the Camargue, and in the middle is an expanse of salt water, the étang de Vaccarès, which communicated freely with the sea by an island-studded stretch of water before it was cut off by the formation of an artificial protective embankment. As seen on a map, the appearance is that of a normal alluvial delta, where the two branches of the river are bordered by fully developed alluvial plains, while between them is a tract of marshy or flooded country, not yet fully reclaimed from the sea, and as such it has generally been interpreted; some strips of ground, too high to be part of the alluvial plain, being regarded as relics of old coastal barriers, now separated from the sea by the advance of the delta.

The description of M. Denizot puts the question in a different light, for he describes the country round the étang de Vaccarès, on the north, the east, and west, as rising to heights of two to three metres, with an undulating surface, the result of subaerial denudation, and in the alluvium forming this high land, he found fossil remains of *Cardium edule*, and other living marine molluscs, at heights of more than a metre above sea-level. As cockles cannot live and thrive above high-water mark, it is evident that, since these deposits were formed below sea-level, there must have been an uplift of the land, and the relation of the present surface to the Roman remains, which are found in this region, shows that this uplift, though extremely recent in the geological sense, must have preceded the advent of the Romans, and probably of their predecessors, the Phœcans and Phœnicians.

Though very recent, this uplift is not the most recent change of level which has taken place. In 1903, Mr. R. T. Gunther established for the neighbourhood of Naples a series of regional changes of level, which ended up by leaving the land some twenty feet lower, relative to the sea, than during the Roman period, and, since then, evidence has accumulated of a similar change of level in other parts of the Mediterranean, from Venice to Alexandria and Carthage, nor is it wanting along the coast of Provence. In the very region of the Rhone itself, remains of Roman buildings have been found below sea-level, in the étang de Vaccarès; and in the Gulf of Fos are remains of old buildings, regarded as remains of the port of Fossæ Marianæ, which was an important seaport in the early centuries of our era.

A very vivid description of these is given by M. Toulouzan, who mentions buildings, and long jetties of stone, as visible beneath the sea in calm weather. The archæology of this writer was so brightly tinged with imagination, that the existence of these ruins has been doubted, or denied, but there is independent evidence of the remains existing under the sea in the Golfe de Fos, and the discovery of remains of Roman construction below sea-level has also been recorded in the étang de Vaccarès. Apart from this, M. Denizot, in the paper referred to, gives evidence of subsidence of the land near Fos, though he denies the possibility of its amounting to anything like nine metres. That some

subsidence of the land has taken place is, therefore, established, but the direct evidence on record, if we except the statements of M. Toulouzan, does not give a measure of it. For this we must look to the changes which have taken place in post-Roman times, which not only give indirect corroboration of the subsidence, but enable its amount to be estimated, as certainly not materially greater than five, or less than four, metres, and the date to be fixed as in the period which elapsed between the beginning of the eighth and the close of the tenth centuries.

One result of the recognition of this change of level is that the current conceptions of the delta in Roman times must be revised. The whole region then stood some twelve to fifteen feet higher above sea-level than at present, and, if the land were again to be raised to this level, the whole of the great expanse of water, forming the étang de Vaccarès and extending to the sea, as well as all the salt lakes, which are in more or less direct communication with the sea, or only cut off by alluvial and coastal barriers, would be converted into dry land. The delta, instead of being smaller than at present, might have extended farther out to sea than now; the great spreads of pestiferous salt marshes, which render the country almost uninhabitable, would be largely or entirely drained, and instead of the subsoil being everywhere so charged with salt that a supply of drinking water can only be procured by storing the rainfall, it would probably be obtainable from surface wells. The country, in fact, would be fertile and habitable, justifying the description of the ancient writers, and accounting for the numerous remains of considerable settlements which have been, and are still being, found. Through this region the branches of the Rhone would flow in channels cut out of the upraised alluvium, with a flood-plain on either side, and the mouths would issue on the sea-face, where the action of the waves, driven directly against the bar by the prevailing storms, would give rise to the same difficulties and dangers of navigation as at present, troubles which Caius Marius solved, in the same way as the French engineers of the last century, by cutting a ship canal from the river to the sea.

With the subsidence in post-Roman times, a change in the conditions took place. In a region where no point rose more than thirty feet above sea-level, the whole of the low lands would be submerged to a greater or less extent; numerous creeks and channels would penetrate the land, converting the gently undulating ground into islands of varying size, separated by channels of varying width and depth; the river, instead of ending on the exposed sea-face of the delta, would debouch into deep and sheltered inlets of the sea; the conditions leading to the formation of a shallow and dangerous bar would be mitigated, and the entry made possible for ships of greater draught and tonnage than before or at present. In the network of channels and expanse of shallow water, resulting from this subsidence, the recovery of land from the sea, by the alluvial deposits of the river, would take place with rapidity, the position of the mouth, and the course of the channel, would be continually changing, until the river once more reached the sea-front of the delta. One region, however, was protected by the accident of configuration of the surface, and while, on either side, the channels were largely filled up by river silt, the great étang de Vaccarès, with the island-studded waters to the south, remained little affected, and have preserved a representation of the conditions which must have been widespread, along the whole of the outer portion of the delta.

Besides the numerous salt lagoons, or étangs, which owe their origin to this subsidence, there are expanses of modern alluvium, which, but for the complete embankment of the river, would still be in process of formation. This modern alluvium, according to M. Denizot, can often be sharply distinguished from the older, prehistoric alluvium, on the undulating, eroded surface of which the Roman settlements were built; in other places the boundary is less easily recognised, but the distinction is none the less complete, and it is largely possible, by an examination of modern maps and a comparison with older ones, to extend his direct observations, and to compile a map which will, at least, give an indication of the general distribution of land and water at the time when the subsidence had ceased, and before sedimentation had been able to make material progress.

Such are the deductions which may be drawn from a purely geological study of the region. It remains to be seen how far they are consistent with, or supported by, historical records.

II.

The western branch of the Rhone, which takes off from the main stream just above Arles, flows past St. Gilles and then bends southwards to enter the sea by the Grau d'Orgon, near Saintes Maries, but the last part of the present channel, from Silvéréal on, dates only from 1552, when the river broke away from its old course. Before that date it had followed another channel, farther west, now known as the *Rhône mort*, past Peccais, to the salt lagoons south-east of Aiguesmortes, and in 1532 was diverted from them by a cut direct to the sea, which became known as the *Rhône vif*, the mouth of this channel becoming the *grau neuf*. Between St. Gilles and Silvéréal the river crosses a great expanse of marsh and swamp, which extends westwards towards the étang de Mauguio, and is separated by a barrier of slightly higher land, an inland delta of the Vistre and Vidourle. M. Denizot refers to this tract, which he recognised as composed of modern, or as we may say, post-Roman alluvium, quite distinct from, and newer than, the older alluvium forming the more elevated undulating surface to the south of it. Even now the greater part of this ground can scarcely be described as dry land; it is mostly swamp and, in all but the most recent maps, considerable tracts are shown as permanently flooded. It bears all the appearance of being a tract which has been reclaimed by river deposits in quite recent times. A relic of this old, and once extensive, sheet of water, which spread over this ground, may be seen in the étang de Scamandre, still about six feet in depth, and evidently bounded by the sloping surface of the alluvial plains of the Rhone on the east and the Vistre on the west.

It is not possible, from the information available of a geological or topographical character, to determine whether this sheet of water formerly extended westwards to the étang de Mauguio; for this we must look

to historical records, and foremost among them may be put the history of St. Gilles. By some writers this place has been identified with the Heraclea, mentioned by Pliny the younger, on the strength of a supposed inscription, which has been wholly discredited by later research. That a Roman town stood where it now stands is certain, but this was not Heraclea, for Pliny mentions that place as one which had become legendary, even in his time, and there is not only no evidence, but a strong presumption, that the St. Gilles of Roman times was not in use as a port. It was otherwise in the eleventh and twelfth centuries, when the Dark Ages were passing away, for at that time St. Gilles was not only a recognised seaport, but also the most important one along this coast. In 1109 Raymond of St. Gilles collected there a fleet of forty ships, to transport an army of four thousand fighting men to the Crusades. Three years later the Knights Hospitaller of St. John founded their first establishment outside the Holy Land at St. Gilles, because it was then the port most used by pilgrims to and from Jerusalem. Mention of the use of St. Gilles is fairly frequent in the records of the twelfth century, and in 1160 the Rabbi Benjamin of Tudela describes it as a flourishing town frequented by visitors from the most distant lands, situated on the banks of the Rhone, and within three miles of the sea. As the sea is now nowhere within five times that distance of St. Gilles, and as there is a continuous strip of what must have been dry land, though possibly penetrated by channels, the sea of the Rabbi could not have been the Mediterranean; it could only have been that expanse of water which has been referred to.

These accounts give no clue as to the direction in which the navigable channel of access lay, but an incident of the wars between the republics of Genoa and Pisa throws light on this subject. Some Pisan galleys, pursued by Genoese, took refuge by ascending the Rhone to St. Gilles; the Genoese, instead of following them, went up the main stream, past Arles and, rounding the point of the Camargue, descended the lesser branch of the river to St. Gilles. The Pisans hearing of their approach fled down stream, as the chronicle reports, by another river and another mouth called the Gradus Capræ, which appears in the French version as Grau de la Chêvre, where the Genoese, in pursuit, captured and burnt some of the galleys and proceeded, searching for more, until they reached the Grau de Montpellier, now called Palavas, where they met a contrary wind and had to return by the river to Arles and so on to Genoa.

This is the last appearance in history of St. Gilles as a port accessible from the sea. In the following century, when Aiguesmortes was founded, in 1240, St. Gilles could no longer have been a seaport; it is certain that there was no direct access to it from the étang de Mauguio, and the Grau de la Chêvre of the thirteenth and fourteenth centuries was the mouth of the old river course, of the *Rhône mort*. This channel, however, seems not to have been navigable, and it is very questionable whether it was meant, in the record of the naval adventure of 1165; if the statement of the Rabbi Benjamin of Tudela can be accepted, the river had not then extended so far, and the narrator, without definitely stating it, implies that the course from the Grau de la Chêvre to Montpellier was in sheltered waters, and not in the open sea. The implication is that the access to St. Gilles was from the westwards, and if so its decline and disappearance, as a port of destination, was due to the closing of this channel on one hand, and the advance of the western and smaller branch of the Rhone on the other.

This conclusion is strongly supported by a study of those remarkable relics of the Middle Ages known as the portolan maps. It is known, from incidental references, that sea-charts of some kind were in use in the twelfth century, but they appear to have been mere sketches, drawn from memory by navigators, of the approaches to individual ports, or of stretches of coast-line; only towards the end of the thirteenth century did the normal portolan appear. This gave a representation of the Mediterranean and Black Seas, and of parts of the Atlantic coasts of Europe and Africa, with a surprising degree of accuracy. The origin and history of these maps have been the subject of much discussion, but it is generally agreed that they were sea-charts made for the use of sailors, that they originated independently of, and were uninfluenced by, any earlier maps, and that, once the type had developed, they went on being reproduced, with merely variations in detail, throughout the succeeding centuries until the seventeenth or even into the eighteenth century.

In the region of the Rhone Delta, the maps all represent a broad inlet of the sea, stretching from Cette to the Rhone, drawn in a conventionalised outline and dotted over to represent shoal water. To this statement an exception must be made of a few of the earliest maps; in the very earliest, the Carte Pisane of the end of the thirteenth century, the representation of the mouth of the Rhone is so purely conventional that no conclusion can be drawn from it; of slightly later date, 1318, are two maps by Petrus Verconte, of very different character and great interest. They represent a great inlet of shallow water, extending from just east of Cette, over the étang de Mauguio to beyond where St. Gilles would be, were it marked on the map; and, more than that, one of these maps also shows a sheet of water, north-eastwards of the termination of this inlet, in the position of the tract of land, between St. Gilles and Beaucaire, which was permanently flooded until it was drained by the digging of the canal from Beaucaire to Aiguesmortes. In neither of these maps does the inlet extend to the Rhone, but stops short, and at the eastern end a river is shown entering it, which must be meant for the western branch of the Rhone.

FIG. 2.—Coast-line between Cette and Cap Couronne, from the Catalan Atlas of 1375. This shows the general type of the representation of the Rhone Delta, which runs, with small variations, through the whole series of the portolan maps, with the exception of the early one by Petrus Vesconte, shown in Fig. 3.

It is impossible to examine these maps without being struck with the facts, that they evidently owe nothing to any pre-existing map of which we have any knowledge, and that they are equally evidently an attempt to represent something which really existed. The author of the general map must have had before him a local chart of this region, probably one of those mentioned above, which had been drawn at a time when St. Gilles was still a port; but this was a century before

the map was drawn, and so the omission of the name of St. Gilles can be accounted for. Vesconte knew that there was no longer a port of St. Gilles, if he knew that there ever had been, and, being of no interest to those for whom the map was made, it was omitted, but the topography he took, directly or indirectly, from the older map. If this map is compared with a restoration of the twelfth century topography, as deduced from modern maps of the region, the agreement, as regards the eastern end of the inlet, is so close, that his representation of the western portion, where direct restoration is more uncertain, may be taken as corroboration of the western approach to the port of St. Gilles.

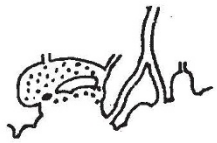

FIG. 3.—Coast between Cette and Cap Couronne, from the map by Petrus Vesconte, dated 1318.

The later history of these maps, so far as it affects this region, may be briefly summed up. The Vesconte map is the last which gives an air of reality to the western channel, and it is probable that in contemporary maps, by other makers, the representation had already assumed the conventional form, seen in the Dulcert map of 1339, and repeated throughout the series of later maps. At the same time, there is a great advance in the representation of the sea-face, which maintained a remarkable correctness until about the middle of the fifteenth century; after that, a change of conditions, by deterioration of the channels of access to Arles and Aiguesmortes, and by the increase in size of the merchant ships, led to this coast being avoided by the mariners who used these charts, and a steady deterioration set in, due to errors introduced by repeated copying, uncontrolled by any check.

From the evidence outlined above we may reconstruct the history of St. Gilles as a seaport. In Roman times it was an inland town, of no great importance, past which one of the branches of the Rhone flowed, as at the present day, but, instead of turning southwards, the river flowed on to the west, in a valley cut out of the upraised alluvium, to where the étang de Mauguio now stands. Then came the subsidence in the Dark Ages, the lower part of this valley became submerged, and an inlet of the sea was formed, with sufficient depth of water to enable ships to reach St. Gilles, which, by 1080, had become so well established that it was selected as the most appropriate landing-place for a princess of Sicily, on her way to the Court of France. The importance and prosperity of the port increased during the succeeding half-century or more, but, once further subsidence of the land had ceased, the alluvial deposits of the river began to advance into the flooded lands until St. Gilles, instead of being a port on an inlet of the sea, became a town on the banks of a small river, and at the same time the rivers Vistre and Vidourle, entering the inlet near its western end, built up a barrier across it. These two causes, combined, made access from the sea to St. Gilles increasingly difficult until, by the end of the twelfth century, its life as a seaport had come to an end. Since then, the remains of this old inlet were gradually filled up by silt deposited from the flood-waters of the rivers, and the process would still be going on, if these rivers had not at last been completely hemmed in by flood-proof embankments.

(To be continued.)

The Centenary of the Railway.

By Engr.-Capt. EDGAR C. SMITH, O.B.E., R.N.

THE celebration of the centenary of the opening of the Stockton and Darlington Railway is an occasion of world-wide interest, for from that pioneer line has sprung the vast network of railways which stretches to the uttermost parts of the earth. It was the first of British public steam railways, and just as the Romans were the great builders of roads, so our race became the great builders of railways. Even as British ships navigate every sea, so railways designed by British engineers traverse every continent. The modern textile industry and the steel industry both had their birth in our isles, but it is probable our three greatest contributions to material progress were the steam-engine, the steam-ship, and the locomotive. Watt and Stephenson, like Shakespeare, Newton, and Faraday, have been eulogised beyond measure, but we are perhaps even now too near the revolutions they set in motion to realise their full significance in the history of mankind.

The Stockton and Darlington Railway was opened on September 27, 1825, when George Stephenson drove his famous engine *Locomotion* from Darlington to Stockton with a train of miscellaneous vehicles and trucks filled with goods and passengers. That great experiment must always be associated with the name of Stephenson, who, however, was but the outstanding representative of the pioneers of the steam railway to whom tribute should be paid. Tracks of wood and wheels of iron had been in use for many years. In 1801 William Jessop had built the first authorised public line, the Surrey Railway. It was probably Jessop who gave us our gauge of 4 ft. 8½ in. By 1820 railways were becoming common, and no fewer than twenty were sanctioned in that year alone. These were worked by horses. In the eighteenth century, Cugnot, Murdock, and Trevithick had all built steam-carriages; and in 1804 Trevithick set a locomotive to work on an iron track in Wales. In this engine he used the exhaust steam as a blast. Two or three years later Trevithick had one of his engines running round a track where Euston Square now stands. Blenkinsop's engines with cogged wheels date from 1812, and about the same time Foster and Hackworth assisted Hedley to construct *Puffing Billy* and *Wylam Dilly*, the two oldest locomotives now extant. Stephenson's first Killingworth engine *Blucher* was built in 1814, his second in 1815, and eight years later, with assistance from Pease, Richardson, and Longridge, he opened his engine factory at Newcastle, where *Locomotion* was built.

Originally projected by Edward Pease as a mineral line for bringing coals from near Bishop Auckland to the sea, the plans for the Stockton and Darlington Railway were passed in 1821, and two years later, largely through Stephenson, powers were obtained for