

interesting deposit, the second instance of the ore being discovered in British Columbia, and the only deposit in the province that shows any chance of proving of economic importance. The ore occurs in a zone of country rock, altered by the infiltration of silica and calcite, bounded on the north by an altered mica-schist. The width of the altered zone has not yet (August, 1904) been determined, but it has been proved scheeliferous for a width of about 12 feet.

The ore so far developed seems to occur under two distinct conditions, as an associate mineral with iron pyrites and galena in small quartz veins; and in 'vugs' in the country rock, sometimes quite pure and at others mixed with a little quartz. The undetermined dark mineral—columbite (?)—occurs in such small quantities as to be of no value. No decomposition products of scheelite have so far been discovered, although the enclosing schist is much discoloured and altered by infiltrating solutions.

The discovery of this rare earth in a place well known for so many years should be remembered when in districts which have been much less thoroughly explored, in which an examination of the heavy materials recovered in the process of Placer Mining may show rare minerals of the greatest economic importance.

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#### NOTICES OF MEMOIRS, ETC.

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NOTES ON THE GEOLOGY OF CYPRUS TO ACCOMPANY A GEOLOGICAL MAP OF CYPRUS. Compiled by C. V. BELLAMY, F.G.S., M.I.C.E., F.R.M.S., late Director of Public Works in Cyprus. Small 8vo; pp. 16. (London: Edward Stanford, 12, 13, and 14, Long Acre, W.C., 1905. Price 6s.)

THE Geological Map of Cyprus<sup>1</sup> and the descriptive text accompanying it are the result of observations extending over a period of five years during which Mr. Bellamy was stationed in the island. He acknowledges the assistance he has received from Mr. A. J. Jukes-Browne<sup>2</sup> and Dr. J. J. H. Teall.

The following is an abridged account of Mr. Bellamy's description of the island:—

1. *Physical Features.*—The Island of Cyprus lies in the extreme eastern basin of the Mediterranean Sea, its distance from the shores of Syria on the east and Asia Minor, or, as it is called locally, Anatolia or Caramania, on the north being about 60 miles in each case. It measures about 140 miles from south-west to north-east, and about 60 miles from north to south; it contains some 3,584 square miles.

<sup>1</sup> Printed in colours; size, 30 by 22 inches; scale,  $5\frac{1}{2}$  miles to an inch (1 : 348,480). [The actual size of map to the margin of the engraved plate is 24 by 18 inches.]

<sup>2</sup> See also paper by C. V. Bellamy and A. J. Jukes-Browne read before the Geological Society of London, January 4th, 1905 (GEOL. MAG. for February, 1905, pp. 87–88).

The coastline is very irregular and indented with several extensive bays, the chief of which are those of Famagusta, Larnaca, Limassol, Akrotiri, Krysoikhou, and Morphou. About midway along the southern seaboard is the irregularly rectangular promontory of Akrotiri, on which is situated the Limassol Salt Lake; this promontory culminates to the south-east in the conspicuous headland of Cape Gata. In the north-east the island tapers off into the remarkable peninsula of the Carpas, which is some 50 miles long and nowhere more than 7 or 8 miles wide, terminating in Cape Andreas, off which is situated the group of barren rocky pinnacles comprising the Klides Islands.

South of Famagusta is the rugged headland of Cape Greco, backed by a table-topped rock, a striking feature to navigators, while at the western and north-western end of the island are Cape Epiphaniou or Acamas and Cape Kormakiti.

The island is very mountainous. Along the northern seaboard stretch the Kyrenia Mountains from Cape Kormakiti until the Carpas commences, and many of their summits exceed 2,000 feet in height, the range culminating in Buffamento, 3,135 feet. In the south-west central portion of the island rise the great masses of the Troödos Adelphi and Olympus Mountains, the summit of the first being Mount Troödos or 'Khionistra,' 6,406 feet above the sea. The general trend of the mountain ranges is in an easterly and westerly direction.

Between these two ranges lie the central plains of the Mesaoria extending from Morphou on the west to Famagusta on the east. These lands, which comprise the washings of centuries from off the adjoining mountain slopes, are of great fertility and are given over to the cultivation principally of cereals, to which, indeed, the whole of the low country is devoted. The mountain slopes are appropriated to the cultivation of the vine, and the summits are clad in pine-trees, ilex, arbutus, juniper, etc. The deep and narrow valleys which seam the mountains enjoy great richness of soil, which yields successive crops of wheat, barley, cotton, maize, millet, potatoes, etc., and supports the olive, mulberry, cherry, hazel, walnut, fig, apricot, apple, and fruit trees of various kinds.

The geology of Cyprus was dealt with exhaustively by M. Albert Gaudry in the "Mémoires de la Société Géologique de France," ser. II, vol. vii (1862), to which a map was attached, but the latter was compiled from a previously existing rough survey of the island of doubtful accuracy. Other writers include MM. Unger and Kotschy, "Die Insel Cypren" (Vienna, 1865), and Mr. R. Russell, C.E., in a "Report on the Existing Water Supply of the Island of Cyprus" (Foreign Office, 1881).

A map of the island on a scale of one inch to a mile, prepared from a trigonometrical survey, executed under the direction of Captain H. H. Kitchener, R.E., was published in 1882. A smaller map, reduced from the Government Survey, has furnished the author with a basis for the geological map noticed in this key.

TABLE OF FORMATIONS.

AGE.	CHARACTER.	DISTRIBUTION.	LOCAL DEFINITION.
Cretaceous.	Compact limestone, marble, etc., and associated igneous rocks.	Kyrenia Mountains and Paphos District.	Trypanian, derived from Trypa Vouno, a summit of the Kyrenia Range.
Highest Cretaceous and Lower Eocene.	Not represented in Cyprus.		
Upper Eocene.	Sandstone, shales, grey marls, conglomerates, and breccia.	Flanks of the Kyrenia Mountains, north and south side of Central Plains, Carpas, and Paphos.	Kythraean, from Kythraea, in the neighbourhood of which this series reaches its greatest development.
Oligocene.	Grey marls, yellow and grey-green clays, gypsum, selenite, alabaster, etc. Tabular white calcareous marls, chalk, flint, sub-crystalline limestones.	North coast, Carpas, north and south of Central Plains, north, east, south, and south-west of Troödos Range.	Idalia beds, derived from Dali, ancient Idalia, where these marls reach marked development. Athienou stone, etc.
Break.	Igneous rocks of the	central and southern	areas.
Pliocene and Pleistocene.	Calcareous sandy limestone, hard or friable. Sands, conglomerates, alluvium.	Low country generally, coast littorals, Central Plains, Foot Hills, etc.	Kyrenia rock, Nicosia Beds, Ag. Paraskevi, Famagusta, Cape Pyla, and Ag. Phyla Stone.

2. *Trypanian Limestone of the Kyrenia Mountains, etc. (Cretaceous).*

The areas occupied by this formation are indicated on the map in pink. The Kyrenia Mountains constitute the northern rampart of the central plains of the island, and commence at a point about 6 miles eastward of Cape Kormakiti on the northern seaboard. The spot is known as 'Skasmata,' a term suggestive of the peculiar physical features of the neighbourhood. From this point, for a distance of 28 miles, the range trends in a direction east by south, and in the neighbourhood of Kythraea changes towards east by north for 30 miles to Komi Kebir at the commencement of the Carpas. Though its extreme length is 58 miles the formation is nowhere more than 3 miles wide, and as the summits of the range frequently reach an altitude of between 2,000 and 3,000 feet, some idea may be gathered of the precipitous nature of these mountain slopes.

The whole of this range consists of hard compact limestones, except for occasional intrusions of igneous rock, and with the exception of a small outlier near Akourso in the Paphos District, these limestones are not encountered in any other part of the island. The characteristics are compact limestones and marbles of several

kinds: white, cream colour, or veined with yellow. They are usually very hard, and include a large variety capable of yielding decorative stone of considerable beauty.

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These limestones and shales are the oldest rocks in Cyprus, and form the foundation on which the rest of the island has been built up. Gaudry remarked that they bear much resemblance to the Cretaceous rocks in other parts of the eastern Mediterranean basin. He compared them with the Hippurite Limestones of Attica, since assigned to the Cretaceous age, and estimates their thickness at 6,500 feet. There is a striking and apparently entire absence of fossil remains in this formation, which causes some doubt as to its correct classification.

At intervals along the axis of the Kyrenia Mountains there occur masses of igneous rocks which have intruded into or through the limestones. These are coloured brown on the map. Their presence may be responsible for the production of the more crystalline varieties of limestone by contact-metamorphism, but the general compression and uptilting of the beds has probably been accomplished by earth-movement which produced the long anticlinal axis of the chain, and so steep is the angle of this axis that the beds are frequently in a nearly vertical position.

Specimens recently collected and submitted to Dr. Teall include augite-biotite-syenite, ophitic olivine-dolerite, and decomposed liparite, from the gorge of the Panagra River near Myrtou; rhyolite or white quartz-felsite near Pentadactylos; with jasper from near Buffamento and other localities.

3. *The Kythraean Series (Upper Eocene).*—This is a formation of sandstone and shales. It is indicated on the map by a green tint, and its beds flank the northern mountains both along their north and south sides, extending from Cape Andreas on the east to Morphou Bay on the west; they also occur on the southern and western slopes of the southern or central range.

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The greatest development to which these beds attain occurs in the neighbourhood of Kythraea, consequently it has been considered convenient to call them the 'Kythraean Series.' They consist of calcareous sandstone shales, brown, grey, or grey-green in hue, and on the southern slopes of the Kyrenia Range, where they are most marked, present a series of billowy undulations, which, since the British occupation of Cyprus, have been known as the 'Hummocks.'

The conglomerates of this series are seldom found except on the slopes of the Kyrenia Mountains in the neighbourhood of the Trypanian limestones; they contain fragments of rock which undoubtedly belong to the latter, but have been separated therefrom and incorporated in the more recent formation. The best instances of the occurrence of these conglomerates are at St. Catherine's Pass, the Akanthou Gap, and east and west of the village of Akanthou; they have not been observed in any force elsewhere. Their con-

stituents are principally water-worn fragments of Trypanian limestones, marbles, and flints.

The breccias are compounded of unworn fragments of the older Trypanian limestones, and are of frequent occurrence along the flanks of the Kyrenia Mountains. They vary in hue and are either blue, pink, yellow, brown, or white, and at times they combine fragments of all these varieties, producing an agreeable effect.

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No fossil remains have yet been found in any part of the Kythraean Series.

Gaudry's description of these beds, as corresponding with the Macignos of Italy, would appear to place them alongside the tassello or allied to the Vienna sandstones or 'Flysch.' They belong probably to the Upper Eocene series. Having regard to the frequent flexures and undulations of these beds, I doubt if their thickness amounts to more than 2,000 feet, though Gaudry put it at 6,000.

4. *The Italian Series (Oligocene).*—Probably the most characteristic of the geological formations represented in Cyprus are the grey friable and the white calcareous tabular marls, the latter of intense whiteness. Occasionally they pass into pure chalk, and in many localities contain quantities of flint—pink, greenish, or translucent—occurring in bands of from four to six inches in thickness. In the grey marls of the Oligocene are intercalated large masses of gypsum and selenite, but their prevailing characteristic is friable matter, yellow, brown, or grey-green, of the consistency of clay.

These two groups of beds are distributed all over the island, and are indicated on the map by a yellow tint. The white marls reach their greatest development on the southern side of the great igneous masses of the Troödos Range. From the neighbourhood of Kophino and Lefkara right through the southern slopes of these hills, they are in great force.

It may be remarked that the white marls occupy that part of the island where the best wine comes from. The so-called 'Wine Villages'—Ag.<sup>1</sup> Ambrosios, Mallia, Vasa, Omodhos, Kilani, etc.—are all within this area, and in this neighbourhood the aspect of the country resembles the wide rolling downs and chalk hills of Wiltshire, but the illusion is dispelled when one perceives the deep gorges with their precipitous sides in which the torrents flow.

The intense whiteness of these tabular marls has, no doubt, a considerable influence upon the temperature of the atmosphere over the region where they are found. The glare from the white soil is extremely painful to the eyes, necessitating the use of coloured glasses to protect them; and the heat thrown back from the bare white rocks is frequently intolerable, aggravated as it is by the infrequency of foliage and shelter-giving trees.

In the neighbourhood of Dali, where the conspicuous development

<sup>1</sup> Ag. (incorrectly printed "Ay." in Mr. Bellamy's Key to the Map of Cyprus) is a contraction for "Ayios, Haghios, = Saint, prefixed to many names of towns and villages in Cyprus.—EDIT. GEOL. MAG.

of white marls and limestones would seem to have suggested to Russell the adoption of the term 'Idalian' to define them, great rounded hills occur in a succession of undulations extending from the neighbourhood of Margi on the west to Athienou on the east, parallel with the Idalia, or Yalias River.

At Athienou these beds pass into a massive granular limestone, of finer quality and less density, which yields a very useful material known as Athienou Stone, easily cut and much used in the manufacture of a number of different utensils for domestic purposes.

Near Psathi, compact and massive beds of fine-grained gypsum of straight cleavage are worked for the extraction of paving slabs known as 'marmoras.' Their cleavage is very true and even, and their texture is such that they can be cut with a saw and smoothed with a plane. These beds also contain a quantity of native sulphur, in veins and nodules.

Ochres are found principally at Mavrovouni near Larnaca, and also near Limassol, where they are worked for terra umbra, a considerable export trade in which is carried on.

Fossil remains are not numerous, except among the white, compact, chalky marls, which contain a few shells and Echinoderms similar to those to be met with in Malta and Sicily. Some of the limestones, however, are largely made up of the minute shells of Foraminifera, and resemble the Globigerina limestones of Malta.

With regard to thickness, it is not easy to give an estimate because of the frequent flexures, but they probably range from 1,500 to 2,000 feet.

5. *The Igneous Rocks of the Central Mountains.*—These rocks form a tract of mountainous ground which extends for a distance of about 60 miles, with an average breadth of 17 or 18 miles. It includes the mountain groups known as the Machera on the east, the Adelphi and Troödos Ranges in the centre, and the Tillyria Mountains on the west; it extends from a point a few miles to the north-west of Larnaca to the shores of Morphou and Krysockhou Bays in a continuous mass. North-east of Larnaca is an inlier in the neighbourhood of Stroullos and Mavrovouni, and another smaller isolated outcrop occurs near Petrophani to the westward of Athienou on the main road, and about half-way between Nicosia and Larnaca.

In the district of Paphos and in the extreme western end of the island are other outcrops, such as that near Fontana Amorosa, near Ag. Epiphanius, Cape Acamas; at Ag. Ismenas, Ag. Yeorghi, Cathika, and Akourso.

The central mountains are the highest ground in the island, and include the great dome-shaped mass of Troödos, the summit of which, 'Chionistra,' is 6,406 feet above the sea, and the Adelphi Range, which culminates in a height of 5,305 feet.

The areas occupied by these rocks are coloured brown on the map.

The ophitic rocks Gaudry calls ophitones and spilites. These terms are now obsolete, but were formerly applied to the rocks which are now known as diabase and dolerite; he also describes a spherulitic rock, which seems to correspond with that now known

as variolite. These are all composed of labradorite-felspar and augite. Aphanites, or fine-grained diabases, also occur.

Basaltic rocks are of frequent occurrence, especially in the Tillyria district; specimens obtained there by me have been identified by Dr. Teall as basalt, and one as augitite, a rock of the limburgite group, but without any olivine.

The serpentine rocks occupy the region of the highest mountains of Troödos, and are bounded by Troöditissa on the south and Evrychou on the north, while they also occur at Phinicarga, Akourso, Cathika, Ag. Nicola, and Ag. Aconas in the Acamas. On the south and east slopes of Troödos they are fibrous and laminar in texture, and contain asbestos.

The eupholites or felspathic serpentines form an intermediate stage between the serpentine and granitone or euphotide, and abound on the side towards Prodromos.

The gabbros are found towards Evrychou and from Prodromos to Akourso. They occur in bands among the masses of diabase and aphanites about Kykkou and again at Ag. Nicolaos in the Acamas.

Diabase is the variety most prevalent among the igneous rocks of Cyprus. They are generally fine-grained, of a grey-green, blackish, or dull-green blue; frequently much weathered, broken up and decomposed, particularly in the neighbourhood of the sedimentary rocks.

Where the Pliocene rocks rest on these igneous rocks they are not altered, and this fact proves that the intrusion of the volcanic rocks took place in the interval between the formation of the Oligocene and Pliocene rocks of Cyprus.

6. *Pliocene and Pleistocene*.—The deposits comprised in the more recent formations, namely, the Pliocene or later Tertiary, and the Pleistocene or Quaternary strata, are indicated on the map by a blue tint.

They extend over the Central Plains, the coast littorals, and are distributed over the foot hills and low country generally, and they rest unconformably on all the older rocks. The Pliocene is represented by calcareous sandstones, conglomerates, sands, and calcareous tufa, while the Pleistocene beds comprise principally gravels, travertine, the alluvial deposits of the Mesaoria, and the raised beach sandstones of the sea-shore. They may be classified under the following heads, namely:—

Kyrenia Rock	}	Calcareous sandstones and marls.
Nicosia Beds		
Raised beaches.		
Conglomerates.		
Alluvium.		

The two first names were adopted by Russell to indicate certain variations of the same formation, soft limestones formed from calcareous sands and consisting almost entirely of minute organic débris, small worn fragments of shells and other marine organisms, loosely compacted together and containing a small percentage of quartz sand. Both are of Pliocene age.

The beds vary slightly in texture, sometimes compact and durable, and at other times soft, friable, and soiling the hands. They are almost invariably disposed in horizontal beds, having a surface coating or crust of tufa-like carbonate of lime. They vary also in colour between light yellow to reddish brown, but its hue is seldom any criterion for its texture. Those beds are found principally at Kyrenia, a little to the west of the town, at the hill of Ag. Paraskevi, Nicosia, at Famagusta, near Cape Pyla, and Cape Gata, where the quality, appearance, and texture are all very similar, namely, semi-compacted, buff-coloured, and easily worked with the tool.

At Yeri a darker, harder, and finer-grained material occurs. Near Kalopsyda and Kouklia sepia-coloured, fine-grained, friable free-stones are found in extensive masses. Near Strongylo and Vatili they are straw-coloured, very friable, and fine-grained, having little or no durability. Near Kyra is a coarse-grained rock, reddish or brownish in hue, and of a durability equalling, if not surpassing, that of the Ag. Paraskevi rock.

At Ag. Phyla, near Limassol, are extensive quarries of a fine-grained, light-yellow, compact stone, possessing many good qualities. At Paphos the texture is coarse, less compact, and more friable than is found among the coarse-grained qualities. It is dark brown in colour. At Skoulli, in the valley of the Krysohou River, a compact, fine-grained, light-yellow rock is found with horizontal veins or bands of dark-grey or greenish-grey matter.

From Yerolakko, on the west of Nicosia, following the banks of the Pedia River as far as Deftera, are large masses of the fine friable yellow variety, changing towards Aradiou into a clayey sand, alternately dark brown or grey green, suggestive of the presence of glauconite. The argillaceous beds near Deftera contain numerous Oyster shells—*O. edulis*.

Towards Laxia, south of Nicosia, are extensive deposits of oyster shells, from the abundance of which is derived the name 'Ostrakoudhies,' given to a prominent hill on the west side of the main road from Nicosia to Limassol. Great masses of friable rock are found towards Ag. Sogomenos, where the texture is very variable and has produced striking results during the process of weathering.

7. *Brief Summary of the Physical History of the Island.*—The oldest strata represented in Cyprus are the Trypanian limestones, the characteristic element of the Kyrenia Mountains. They have been assigned to the Cretaceous age, and form the foundation or platform on which the newer rocks have been laid down. Apparently they formed part of an ancient land-surface during the greater part of the Eocene period. Then came a subsidence of this land beneath the sea, and in this sea were deposited the sandstones of the Kythraean Series, which is referred to the latest part of the Eocene period.

The absence of fossil remains in the older strata led some Continental geologists to believe that their deposition took place at so great a depth under the sea as to be below the zone of life,



presumably in Mediterranean waters; but so far as the Kythraean beds are concerned this is disproved by the discovery of tests of *Globigerina* in a slice of Macigno by Mr. Jukes-Browne. The gritty material of these calcareous sandstones is, however, of volcanic origin; they may, in fact, be accumulations of volcanic dust and felspathic grit ejected from a volcano, and spread out over the sea-floor of the period.

The absence of organic remains in the Trypanian limestones may be accounted for by marmorosis and other metamorphic changes which have taken place since they were originally deposited.

Above the Kythraean Series come the grey Oligocene marls, containing gypsum and alabaster, and above these the white (Idalian) marls and chalks, which prove that the subsidence had continued until the water was of great depth and deposits similar to modern oceanic oozes could be formed. The subsidence was brought to an end by an epoch of volcanic disturbance accompanied by general upheaval. The Pliocene strata of Cyprus rest unconformably upon the older rocks, and moreover they belong to the younger members of that series, so that here we have a second break in the geological history of the island. During this interval, and at a time corresponding with the early Pliocene stage, the igneous rocks would appear to have emerged and the mountain ranges came into existence, only the summits of which, however, then showed above the sea, constituting groups of islands, now the Troödos Mountains on the south and the Kyrenia Hills on the north. Among these islands spread the waters of the Pliocene sea, beneath which the sandstones, conglomerates, and associated strata, all fruitful in fossil remains, were being deposited. Subsequently the waters receded and revealed the island, whose emergence may have been perpetuated in the fable of Aphrodite rising from the waves. This introduced the Pleistocene period. Later came high elevation and torrential floods, which were responsible for much of the land sculpture, and which changed the physical aspect of the country into the condition in which it is now found. May it not be assumed that this event also is still recorded in the annual ceremony of the 'Kataklysmos'?

Recent discoveries in Egypt and Syria indicate that in early Pleistocene times there existed, to the south of Cyprus, a great inland sea, leaving dry land all around Cyprus, which connected it with the mainland of Asia on the north and with Syria on the east. It was at this period that the mammalia, whose remains have recently been discovered by Miss D. M. A. Bate in the Pleistocene deposits of the caves among the Kyrenia Mountains, made their way over from the mainland. They were no doubt denizens of the great plains, now submerged, which separated the mountains of Cyprus from those of Syria and Asia Minor, and whose grazing-grounds were subsequently restricted to the estuaries of the Pedia and Yalios, where now stretch the fertile corn lands of the Eastern Mesoria.

8. *Economics*.—The industrial uses to which the rocks of Cyprus

are put are numerous and varied, and, according to tradition, the island possessed at one time great mineral wealth, but there are now few indications of the presence of ore of any description in quality or quantity sufficient to encourage systematic mining operations.

The following are among the principal products of the rocks of Cyprus :—

FORMATION.	PRODUCTS.
TRYPANIAN LIMESTONE (Cretaceous).	Marble of various kinds, formerly used by the ancients in their temples and palaces. Lime, produced at Kythrea, Dikomo, Kazaphain, etc. Clay, used for covering the flat roofs of the native houses.
IGNEOUS ROCKS.	Copper, according to tradition. The only mine now working is at Lymni, in the Paphos District. Iron pyrites in abundance. Asbestos, among the serpentines of Troödos. Puzzolana. Terre verte. Alum. Pottery earth. Gems, rock crystal or 'Papho diamonds.' Road-metal, etc.
KYTHREAN SERIES (Eocene).	Building-stone. In some localities a clay is found containing a small percentage of carbon.
GREY MARLS (Oligocene).	Gypsum, for plaster of Paris. Alabaster and selenite. 'Marmoras' or paving slabs. Sulphur.
WHITE TABULAR MARLS (Oligocene).	Athienou stone, for fire bricks, hearthstones, domestic utensils of various kinds. Flint, for 'dhoukanis,' a species of threshing implement. Terra umbra. Building-stone. Road-metal, etc. Mineral springs are also found issuing from these marls impregnated with sulphur.
PLIOCENE AND PLEISTOCENE.	Building-stone, etc. Salt, from the salt lakes of Larnaca and Limassol. The alluvial deposits of the Mesaoria are remarkable for their depth and loamy character, constituting a soil of great fertility, and eminently suited for the cultivation of cereals, etc.

## R E V I E W S .

I.—PALÆONTOGRAPHICAL SOCIETY OF LONDON, Vol. LVIII. Issued for 1904. (London: printed for the Palæontographical Society; agents, Dulau & Co.; December, 1904.) Containing 28 pages of introductory matter, and—