COMMONWEALTH OF AUSTRALIA.

REPORTS

ON THE

GEOLOGY OF THE FEDERAL CAPITAL SITE

BY

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REPORTS ON THE GEOLOGY OF THE FEDERAL CAPITAL SITE.

Department of Mines,

Sydney, 4th January, 1911.

SIR,

The geological survey of the Canberra Federal City site has now been completed, and a map of the same has been prepared for reproduction.

The rocks composing the city site consist of a somewhat contorted and folded sedimentary series of sandstones and quartzites, shales, slates, limestones, and volcanic tuffs, and this has subsequently been intruded by an igneous series, consisting principally of quartz-phorphyries and quartz-felsites.

SEDIMENTARY ROCKS.

The sedimentary rocks, more especially the limestones, contain fossil corals, Brachiopoda, and Trilobites, which show that they are of Upper Silurian age. The following fossils have been identified by Mr. W. S. Dun, Palæontologist to the Geological Survey :—

1. From immediately west of Glebe Farm, City site—

Corals	*Halysites australis.*
	Favosites.
	Heliolites.
	Cyathophyllum.
Brachiopoda, Leptoena, and numerous small brachiopods.	
Trilobite	*Encrinurus.*

2. From under Bridge, Woolshed Creek, Yass-Queanbeyan Road—

Crinoid	Stem ossicles.
Brachiopoda	*Strypa reticularis, Var.*
	Orthotetes, Young (? O. Shearsbyi).
	Leptoena.
	Orthis.
Trilobite	*Encrinurus.*

SANDSTONE AND QUARTZITE.

One of the most noticeable features of the City Site is the occurrence of thick beds of buff-coloured sandstone, which occupy a considerable area, including Black Mountain, at the north-west corner of the surveyed area. Although similar sandstones are very characteristic of the Devonian formation, they have not hitherto been recognised, in anything like such important deposits as are here noticeable, amongst rocks of Silurian age in New South Wales. It was, therefore, a surprise to find them conformably bedded with limestones containing Upper Silurian fossil remains.

These sandstones have been used locally to some extent for building purposes, the Canberra Anglican Church being constructed principally of them. This church is of considerable age, and the stone has worn fairly well. Nevertheless, it must be admitted that the sandstone is not of first-class quality for building purposes. It is rather dense and fine-grained, but, besides being iron-stained in places, it has certain defects in the shape of flaws and oblique joints, which make it liable to scale and crack. These defects are attributable to lateral pressure caused by earth movements, which have thrown the sandstone beds in the vicinity of Black Mountain into anticlinal and synclinal folds. Small quarries have been opened in only two or three places on the Black Mountain, and, therefore, the question as to whether a better quality of building stone is not obtainable cannot be said to have been definitely decided.

In this connexion it may be mentioned that prospecting at a depth by boring or sinking would scarcely be likely to reveal stone of a better quality anywhere in the vicinity of the folds already referred to, but it is possible that if the rocks were tested where the beds are less disturbed, that is to say as far away as possible from any of the anticlinal or synclinal folds, the chances of obtaining superior building stone would be greater. With regard to the size of the blocks which it might be possible to obtain from these beds, it may be mentioned that at the principal quarry on the Black Mountain an undressed block measuring 5 feet by 2 feet by 1 ft. 6 in. was observed, and it would probably not be difficult to obtain a supply of stones of similar or larger size.

Near their contact with the intrusive igneous rocks (which will presently be referred to) the sandstones have been transformed into dense quartzites, and all traces of their bedding planes have been entirely obliterated. Numerous small isolated patches of quartzite remain to indicate where portions of the sandstone beds were enveloped, but not completely absorbed, by the molten magma which intruded them.

SHALES.

Interbedded with the sandstones are certain thin-bedded shales, which, for the most part, are yellow, but in places, owing to the presence of peroxide of iron, they assume a chocolate colour. The yellow shales offer less resistance to denudation than either the ferruginous shales, the sandstones, or the quartzites, and consequently they are found principally occupying the valleys, while the hills are formed of quartzite, sandstone, or ironstone. The iron in the chocolate shales has a tendency to segregate, forming deposits of limonite or brown iron-ore, which, to some extent, protects the underlying rocks from denudation. It not infrequently happens, therefore, that the low rounded hills are found to be formed of these ferruginous shales, the summits being composed of an ironstone cap. The ironstone is occasionally of good quality ; but the deposits, being superficial, are not of sufficient extent to constitute a source of ore for smelting purposes.

SLATES.

Deposits of bluish fissile slates also occur within the city area. These rocks may be recognised by their cleavage (as distinguished from their true bedding planes) which causes their outcrops to appear as if vertically bedded. Under the microscope they are seen to be tuffaceous, being composed principally of volcanic ashes, which have been deposited in water and subsequently consolidated. So far as can be seen by their limited exposures these slates are not of sufficiently good quality to be utilized as roofing slates, though it is probable that careful prospecting within the Federal Territory might result in the discovery of some deposits suitable for door-steps, paving-stones, and other analogous purposes.

Some of the shales in the vicinity of Canberra might possibly be found to be suitable for the manufacture of machine-pressed bricks, and it is suggested that trial samples of a few tons in weight might be forwarded to some of the brickworks of Melbourne or Sydney for experimental purposes. One or two of the most likely looking deposits have been indicated to Colonel Owen, who, it is understood, intends to have some trials undertaken.

LIMESTONES.

Beds of limestone are numerous within the city area and the surrounding territory, though none of the individual deposits is remarkable for its thickness ; the most extensive in regard to length occurs along the northern slope of the Red Hill, and is indicated on the geological map by the figures 5, 6, 7, while the thickest beds observed are on the northern side of the Molonglo River, and can be recognised on the map by the figures 8, 9, and 10.

Most of these limestones appear to be of good quality for the manufacture of mortar and hydraulic cement. The following analyses were made by Mr. Mingaye (Analyst to the Geological Survey of New South Wales) of samples taken from four of the deposits. The figure at the head of each analysis indicates the locality of the bed of limestone on the geological map.

Limestone from (3)—

Partial Analysis.

Water	0·05
Calcium carbonate	96·80
Magnesium carbonate	0·66
Ferric oxide and alumina	0·66
Gangue	1·90
	100·07

Limestone from (8)—

Partial Analysis.

Calcium carbonate	96·24
Magnesium carbonate	2·05
Ferric oxide and alumina	0·26
Insoluble in acids	1·68
	100·23

Limestone from (5)—

Chemical Composition.

Water	0·84
Silica	22·60
*Alumina	6·26
Ferric Oxide	0·30
Ferrous oxide	1·17
Lime	37·72
Magnesia	1·53
Potash	1·37
Soda	0·45
Phosphoric anhydride	0·16
Carbon dioxide	27·76
	100·16

* Including any Titanium dioxide present.

Limestone from (11)—

Partial Analysis.

Calcium carbonate	97·79
Ferric oxide and alumina	0·60
Gangue	1·15
Magnesium carbonate and undetermined matter	0·46
	100·00

CALCAREOUS TUFFS.

In proximity to the limestones of the Red Hill occur beds of a calcareous tuff which presents features of some interest. It consists of a dense, fine-grained, bluish rock of considerable hardness, which presents a banded and much corroded appearance when weathered. This appearance is caused by the action of the atmosphere in dissolving and removing, along well-defined bands, a proportion of the carbonate of lime which the rock contains, whilst intermediate zones, being apparently free from lime, remain unaltered by the weathering influences. Analyses of several samples of this rock show that it contains varying proportions of carbonate and silicate of lime, so that it may be regarded as a more or less siliceous limestone. This fact suggested the possibility of its being useful in connexion with the manufacture of hydraulic cement. It is understood that the Federal Government will require large quantities of Portland cement in connexion with the building of the capital city, as concrete is entering more and more largely into engineering and architectural designs, and the establishment of a Government cement factory will therefore probably be advisable with a view of saving the cost of freight on supplies from existing establishments. The occurrence, at or near Canberra, of deposits of limestone suitable for this purpose may be regarded as assured; but it is also possible that careful experiments with the calcareous tuff above referred to may prove it to be of some value when mixed with an additional proportion of lime. The following analyses were made in the Geological Survey Laboratory of samples of this rock from five localities (indicated on the map in each case by the reference figure), and it will be noted that the percentage of silica varies from 30 to 60.

	(1)	(2)	(4)	(6)	(7)
Water	1·34	1·30	0·80	0·73	0·68
Silica	36·18	48·05	46·12	30·23	60·02
Alumina	10·27	10·93	14·61	8·38	15·54
Ferric oxide	0·40	0·80	1·20	1·10	1·20
Ferrous oxide	3·32	2·78	3·42	2·97	5·40
Lime	30·08	29·24	27·65	34·63	10·48
Magnesia	2·65	2·95	3·90	2·25	1·84
Potash	2·10	0·11	0·31	1·67	4·30
Soda	0·23	0·01	0·85	0·83	0·38
Phosphoric anhydride	0·23	0·10	0·22	0·15	trace
Carbon dioxide	13·12	4·04	1·27	17·50	0·30
	99·92	100·31	100·35	100·44	100·14*

* Manganous oxide and strontia, traces.

An experiment was made by Mr. Mingaye with a sample of about 12 lbs. of the rock from (7), which it will be seen contains a higher percentage of silica than any of the others. The rock was finely ground mixed with a proportion of lime to accord with the composition of hydraulic cement and calcined. The result of the experiment was not satisfactory, nevertheless, I think it would probably be worth while to have some further experiments made, if possible, in a cement factory where the necessary conveniences are available, and where the operators are more familar with the requirements of the manufacture. Moreover, it is probable that specimens of the rock containing a lower proportion of silica than the one referred to above might yield better results.

CRYSTALLINE TUFFS AND LAVAS.

At the north-east corner of the city site there is a complex area (including Mounts Ainslie and Russell) consisting of crystalline volcanic tuffs, tuffaceous shales, and lavas. Some of the tuffs are very coarse in texture, containing angular inclusions up to an inch in diameter, while others are almost indistinguishable from the quartz porphyries which are interbedded with them. The detailed classification of all the rocks within this area has not been attempted, as it would require more time than I was able to devote to the work, while the result would be of purely scientific interest.

OCCURRENCE OF GOLD.

Some very old alluvial gold workings, the position of which is indicated on the map, were noticed in a gully within the area last alluded to, and the remains of an old puddling machine were also discovered. The rock in the immediate vicinity of these alluvial workings was recognised as a nodular felsite, and it is interesting to note that at Panbula, near Twofold Bay, New South Wales, gold, which was at first worked in alluvial deposits, was ultimately traced to a matrix consisting of a rock identical with that just mentioned. Extremely rich chutes of gold were extracted from the Panbula felsites, in the vicinity of joints in the igneous matrix, but never more than a few feet away from a narrow but barren quartz reef, which was known by the name of the pilot vein or indicator. The similarity of the conditions prevailing at Panbula and Canberra suggests the possibility of workable deposits of gold occurring in the felsite rocks of the last-named locality.

On the higher points along the course of the Molonglo River, there are deposits of coarse gravel which mark the level of the old river bed in late Tertiary or Pleistocene times. These deposits are occasionally 2 or 3 feet deep, but as a rule they have been redistributed, and now only a surface layer of scattered pebbles remains. The pebbles are well water-worn, and consist principally of quartz.

A belt of recent alluvium extends along the present course of the river for an average width of about a quarter of a mile on each side of it. This deposit is of a rather sandy character and in places forms wide river flats, which have been under cultivation for many years, good crops of maize, lucerne, wheat, oats, and barley being obtained when the seasons are favorable. Shallower alluvial deposits occur in the valleys away from the river, and where these valleys intersect or drain the belts of igneous rocks, clays have been produced which should be suitable for the manufacture of bricks by the ordinary hand process.

IGNEOUS ROCKS.

A well-defined belt of igneous rocks, consisting principally of quartz porphyries and quartz felsites, stretches from north-west to south-east across the city area, having intruded the sedimentary series, tilting and contorting the beds, and converting the sandstones in many places into quartzites. This belt is an off-shoot from an extensive "massif" of quartz porphyry, which appears to be the dominating rock of the district, and which is typically developed in the mountain known as Mugga Mugga, a mile or two to the south of the city site. Another offshoot of this "massif" intrudes the gritty tuffs which occur near the south-west corner of the city. This quartz porphyry has characteristics which will without doubt make it valuable as an ornamental building stone. The matrix is of a dark bluish-green colour, and through this are scattered crystals of quartz and felspar. It is very similar in texture, hardness, and durability to a medium-grained granite. It should be possible to obtain stones of this rock of a size suitable for any ordinary building purposes, and it is probable that Mount Mugga Mugga would be the most suitable locality for a quarry having in view the quality of the rock there and its proximity to the centre of building operations.

The other crystalline rocks which have been mentioned, viz., fine-grained felsites, tuffs, quartz felsites, &c., have, as a rule, been subjected to a considerable amount of denudation; they do not, therefore, exhibit imposing outcrops, and are very much decomposed at the surface owing to the influence of atmospheric agencies. If sunk upon for a few feet they would, without doubt, develop into dense and durable rocks, but it is very questionable whether any of them would be found to be so suitable for building purposes as the quartz porphyries of Mount Mugga Mugga.

In conclusion, it may be stated that the general geological conditions of Canberra are extremely favorable for the purposes of a Federal Capital City. The prevailing rocks are, without exception, suitable for the foundations of heavy structures, and would offer no insuperable difficulties in the construction of tunnels and pipe-lines for sewerage, or of surface reservoirs for water-supply purposes.

A preliminary report has already been furnished in reference to what appears to be the most favorable site for a weir across the Molonglo River, and it may be added that there is no apparent reason for anticipating any difficulty in carrying out the suggested scheme for an ornamental lake in the centre of the city area.

EDWARD F. PITTMAN,
Government Geologist and Under-Secretary for Mines.

Colonel Miller, I.S.O.,
Secretary for Home Affairs,
Melbourne.

Department of Mines,
Sydney, 14th March, 1911.

SIR,

In further reference to my Report of the 4th January last on the geology of the Federal Capital Site, I have the honour to forward the following additional remarks:—

Building Stone.—In my previous Report I described the sandstones of the Black Mountain, and the quartz porphyry of the Mugga Mugga Range. The latter rock also occurs in many other places within the Federal Territory, and varies considerably in texture, much of it being finer-grained than the deposit already alluded to. For building purposes the Mugga variety of the rock is probably the most suitable, besides being the most conveniently situated in regard to the city site.

At Tharwa, on the southern side of the Murrumbidgee River, there is an area of granite which should be of considerable value for architectural and engineering purposes. This rock is of a greyish colour, and is capable of being quarried in large blocks. Tharwa is about 18 miles from the city site, with which it is connected by a fairly good road. I propose to have specimens of the granite and porphyry polished, and will forward them to you when completed.

Run-off of the Cotter River.—In your letter of the 6th July, 1910, you requested me to report upon the cause of the high run-off of the Cotter River, and to state whether there are deposits or formations which tend to equalize the river flow. I have investigated this matter, and am of opinion that the run-off of the river, though undoubtedly high, is perfectly normal. Through the courtesy of Mr. C. R. Scrivener, I have been supplied with the available records of the rainfall within the catchment area and of the discharge at the mouth of the Cotter. Rain gauges have been placed at two sites only, viz., at the head of the river and at its junction with the Murrumbidgee. It is assumed that the mean of the readings at these two localities will represent fairly accurately the average rainfall over the whole catchment area, as the latter is only about 28 miles long, and has an average width of about 5½ miles. Unfortunately, however, complete records of the rainfall at the head of the Cotter are only available for four months, viz., October, November, and December, 1910, and January, 1911; while for the Cotter Junction they include September, 1910, in addition to the months just mentioned. It was only possible therefore to estimate the mean rainfall over the whole catchment area for the four months, viz., October, November, December, and January, and this was found to amount to 15·18 inches. The discharge of the Cotter River for the same four months amounted to 1,368,464,221 cubic feet. The area of the Cotter catchment has been estimated at 160 square miles, or 4,460,544,000 square feet, therefore the discharge just alluded to would cover the whole of the catchment area to a depth of 3·681 inches, and as the rainfall over the same area for the same period amounted to 15·18 inches, it follows that the ratio of run-off to rainfall was 24·25 per cent. This estimate can only be regarded as approximate in view of the fact that only four months' records were available, but it is probably below the actual truth, because the loss by evaporation would be less (and consequently the proportional run-off would be greater) during the winter months than during those of summer. It is worthy of note that if the rainfall and discharge for the *three* months ending 31st December, 1910, be taken a ratio of 27·04 per cent. is obtained, while for the *two* months ending 30th November the ratio is 32·85 per cent.

These figures are not exceptional. Mr. L. A. B. Wade, of the Public Works Department, informs me that from observations made on the Tumut River, at Tumut, over a series of five years, the percentage of rainfall discharged was found to vary from 34·7 up to 53·1 per cent. There is a probability, however, of these estimates being too high, for the reason that the rainfall records are nearly all for stations in the valley, and that on the highlands at the head of the catchment, where the rainfall is greatest, the records are not taken because there is no settlement there.

The principal factors which tend to reduce the run-off of a river are percolation and evaporation, and the former is governed by the degree of porosity of the rocks which form the catchment area; thus the proportion of rainfall discharged by the Murray River was at least twelve times greater than that of the Darling for the nine years ending 1903. This result was undoubtedly due to the fact that whereas the catchment area of the Murray is composed of hard crystalline rocks such as granites, metamorphic slates, &c., the tributaries of the Darling, in their upper reaches, all pass over beds of very porous sandstone; consequently a large proportion of the rain which feeds the tributaries of the Darling is absorbed by porous rocks, and percolates downwards to increase the artesian supply of the Great Australian Basin.

The loss by evaporation is governed by the topographical features of the catchment area as well as by its geographical position. Both evaporation and absorption therefore assist in reducing the proportional discharge of the Darling as compared with the Murray.

In the case of the Cotter River I am of opinion that the high ratio of run-off to rainfall is due solely to the following three causes, viz.:—

(1) The steep inclination of the mountains forming the sides of the catchment area, as a consequence of which the rain water rapidly finds its way to the river.

(2) The impervious nature of the rocks occurring within the area. These rocks consist of crystalline porphyries and tuffs, and indurated slates and shales, and such rocks not being favorable to absorption, it follows that there is a minimum of loss from that cause.

(3) The fact that the bed of the Cotter occupies a narrow ravine and is very considerably sheltered by oak trees and small scrub, which have a tendency to reduce evaporation to a minimum.

In view of the many condemnatory statements in regard to the Cotter which have appeared in the daily press, I may perhaps be permitted to express a doubt as to whether any unprejudiced person could, after inspection, entertain an unfavorable opinion of it. Admirable as the Yass-Canberra site undoubtedly is for the purposes of the Federal Capital, the most impressive feature of the whole territory is in my opinion the Cotter River. It can be truly described as an ideal mountain stream, and both in regard to purity and quantity it will form a magnificent water supply for a large population. The only disadvantage that can be cited against it is the fact that its altitude is not sufficient to allow of the water being brought to Canberra by gravitation. It is notable that Mr. Scrivener's records of run-off for the past twelve months show that the mean supply for that period was at the rate of over 50,000,000 gallons per day.

I have the honour to be,

Sir,

Your obedient Servant,

(Signed) E. F. PITTMAN,

Government Geologist of New South Wales.

Colonel Miller, I.S.O.,
Secretary for Home Affairs,
Melbourne.

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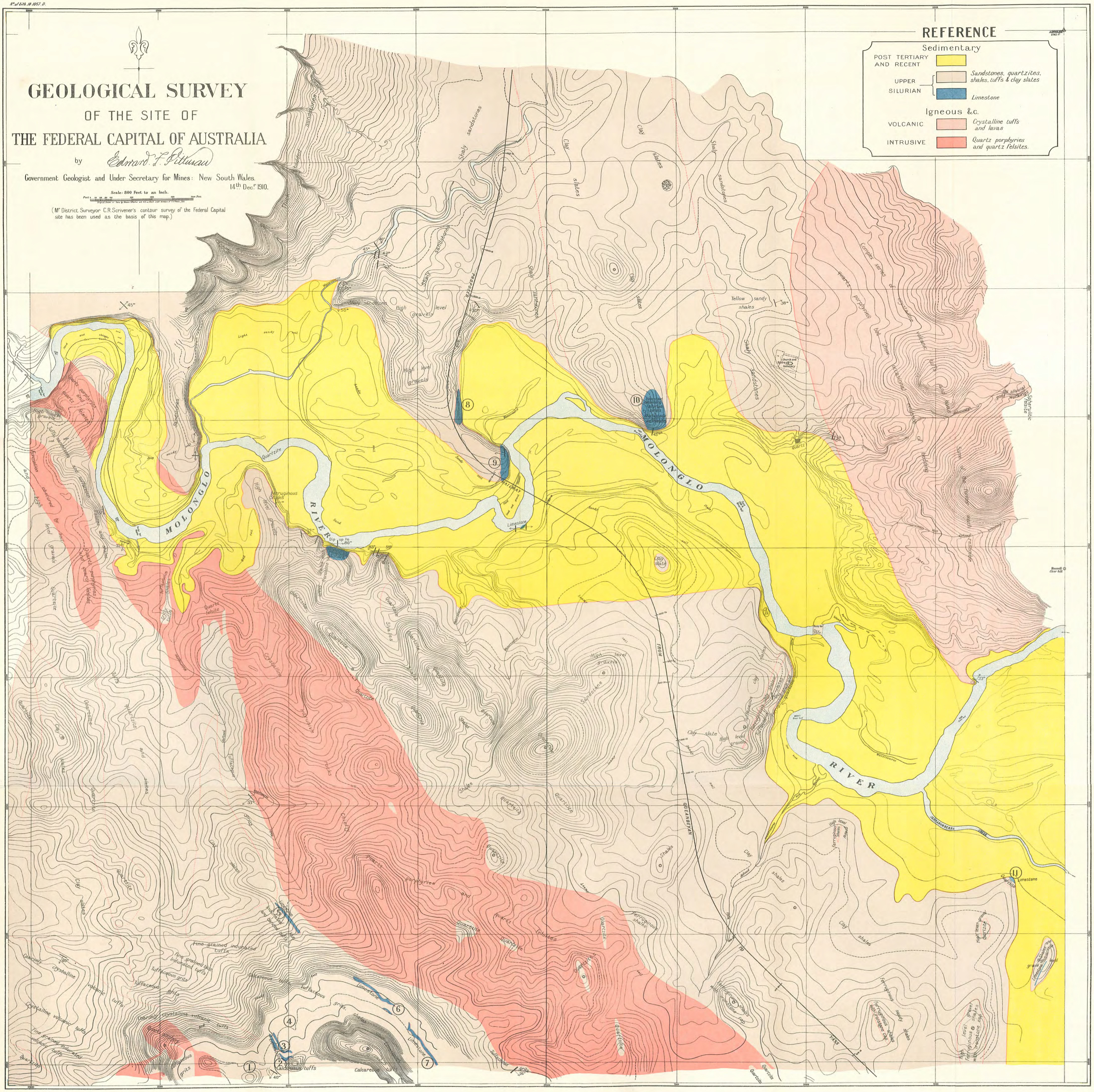
GEOLOGICAL SURVEY
OF THE SITE OF
THE FEDERAL CAPITAL OF AUSTRALIA
by Edward F. Pittman
Government Geologist and Under Secretary for Mines: New South Wales.
14th Decr 1910.
Scale: 800 Feet to an Inch.
(Mr District Surveyor C.R. Scrivener's contour survey of the Federal Capital site has been used as the basis of this map.)
REFERENCE
Sedimentary
POST TERTIARY AND RECENT
UPPER SILURIAN
Sandstones, quartzites, shales, tuffs & clay slates
Limestone
Igneous &c.
VOLCANIC
Crystalline tuffs and lavas
INTRUSIVE
Quartz porphyries and quartz felsites.
AINSLIE 2762 ft
MOLONGLO
RIVER
MOLONGLO
RIVER
Clay shales
Shaly sandstones
Yellow sandy shales
High level gravels
Quartzite
Limestone
Crystalline volcanic tuffs
Calcareous tuffs
Quartz porphyries and quartz felsites