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SUMMARY NOTE ON THE GEOLOGY OF THE CENTRAL AND CAPITAL HILL AREAS OF CANBERRA.

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This note was prepared at the request of the National Capital Development Commission. The statement on the Central Area is a modification of the summary of Record 1969/11 and that on Capital Hill was prepared in advance of a report on the Capital Hill Area.

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INTRODUCTION

The Central Area is situated northeast of Capital Hill, between Commonwealth and King's Avenues, and the southern shore of Lake Burley Griffin. It is described in some detail by Gardner (1969). The Capital Hill Area is that enclosed by State Circle. A preliminary report is available (Gardner, 1964) on the geology, together with the results of a reconnaissance refraction seismic survey, using a single channel seismic timer. A seismic survey along the route of a proposed tunnel was conducted by Polak & Wainwright (1965). The information on the Central Area is derived from the results of numerous site inspections and investigations, geophysical surveys, and diamond drilling. That on Capital Hill is derived from the reconnaissance seismic and geological surveys mentioned above. No drilling for geological purposes has been carried out.

CENTRAL AREA

The Canberra Central area was formerly occupied by a low rounded ridge that ran north-northeast from Capital Hill. The crest rose to two rounded hills, one of which is Camp Hill; the other, Cork Hill, was situated northeast of King George Terrace; it was stripped and the site levelled several years ago. Lower lying parts of the Central Area, northwest and east of the former Cork Hill, have been built up by fill.

The Central Area is cut from northwest to southeast by the Acton Fault,* which runs approximately along the line of King George Terrace. On the northeastern side of the fault, the bedrock consists of Lower Silurian sedimentary rocks, and on the southwestern side, of Lower Silurian sedimentary rocks resting unconformably on Ordovician sedimentary rocks. Faults, which trend north and northeast, have been mapped on both sides of the Acton Fault. All fresh rock (that is unaffected by shearing, faulting or weathering) in the area is amply strong to support heavy building loadings. Fresh rock would need to be excavated by explosives. The effects of faulting, shearing and weathering are described below.

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*The faults and shears referred to in the note are geologically ancient features; they are breaks in the earth's crust along which movement has taken place in the past. The effect of this was to bring different rock types into contact and to permit water to penetrate deeply, thereby producing, by weathering, deep zones of soft rock, commonly with mechanical properties approaching those of soil. The faults and shears are not active and do not create earthquake risks.

The sedimentary strata northeast of the Acton Fault form the eastern limb of a broad anticline. The eastern limb has been displaced westwards along two reverse or thrust faults, and has covered the crest and adjacent parts of the anticline. A normal fault occurs on the east, near King's Avenue Bridge. The sediments are calcareous, and the younger beds in the area contain thick bands or lenses of limestone.

Southwest of the Acton Fault, in the Camp Hill area, the Lower Silurian sedimentary strata form an anticline. The core of this fold consists of siltstone which contains interbeds and thin sequences of very fine-grained sandstone. This is overlain by the State Circle Shale, which ranges in rock type from silty and fine sandy shale to massive mudstone or claystone. A short distance southwest, on Capital Hill, the unconformity between the Silurian strata and resistant Ordovician sandstone is exposed in outcrop. The bedrock below Camp Hill is extensively sheared and crushed, though local patches of it, up to 40 feet in length, are little fractured.

Weathering of the rocks below the surface extends to considerable depths throughout most of the Central Area, depending partly on rock type and partly on the prevalence of joints and other fractures which permit the entry of groundwater. In the course of weathering, cavities are formed within fairly pure limestone through solution by groundwater that enters the rock mass along fractures. These cavities are well developed where the fractures are interconnected - for example, in and near faults. The limestone in the blocks between fractures is commonly quite fresh. The presence of cavernous limestone may cause much difficulty in the founding of buildings, as evidenced by experience at the Secretariat site. At other localities, such as the Canberra Community Hospital site, weathering by solution along sets of intersecting joints resulted in the formation of residual limestone blocks and boulders, generally set in clay; foundation preparation is costly at such sites.

Limestone that contains argillaceous (clayey) impurities becomes covered with a thin layer of clay that retards further weathering by preventing free access of groundwater; as a result, argillaceous limestone and highly calcareous mudstone, in thick beds that are not closely jointed, tend to weather slowly and to be free from solution cavities. At a proposed Conference Centre site adjacent to Albert Hall, impure limestone below a cover of soil and alluvium is weathered to a depth of only a few inches. At the southern abutment of Commonwealth Avenue Bridge, hard calcareous mudstone provides sound foundations at a shallow depth. This type of bedrock provides strength and rigidity far in excess of foundation requirements; it is, however, not easily excavated. Where the proportion of calcium carbonate is lower, the argillitic beds tend to weather more deeply. Such conditions apply at the National Library site, where satisfactory foundations were available for spread footings immediately below the basement, about 15 feet from the surface.

Non-calcareous argillitic sedimentary rocks, in thick or massive beds that are not closely jointed, tend to weather slowly. Fairly fresh thick-bedded mudstone occurs locally in the northwest of Camp Hill. However, the bedrock throughout nearly all the Camp Hill area is closely jointed, fractured and sheared, and is weathered to considerable depths. Building foundation design will need to be based on small to moderate unit loadings. The sandstone and siltstone in the Central Area also tend to weather deeply. This is observed in the old Cork Hill area, on the northeastern side of the Acton Fault. Weathered sandstone, however, is not subject to volume changes in the course of wetting and drying, nor to large settlement under load; good foundations, at least for moderate loadings, may be expected at shallow depths. The core of the Camp Hill anticline, though named the Camp Hill Sandstone, consists predominantly of siltstone; it is weathered and decomposed to considerable depths. In designing foundations, it would be necessary to assume that, locally, this weathered rock would tend to have the mechanical properties of a clayey silt rather than a siltstone.

Very poor foundation conditions are found in the fractured and altered bedrock along some of the faults. The fractures have provided access for groundwater, and also, at several of the construction sites in and near the area they have, in past geological time, permitted the rise of heated mineral waters from great depths. The hydrothermal solutions have brought about thorough decomposition of some of the bedrock at Commonwealth Avenue and King's Avenue Bridge sites.

The western and eastern parts of the Central Area, and a narrow strip on the northeast are covered by ancient river alluvium, which has weathered in situ since being deposited. In most of the alluvium the inter-granular pore space is filled by clay and other products of weathering, and the alluvium has low permeability. In some places, the weathering products have been removed by circulating groundwater, leaving loose, highly permeable sand and gravel. In the higher part of the Central Area, near the axis, the base of the alluvium is above the top level of the lake water. However, the weathered bedrock surface, on which the alluvium was deposited, slopes down towards the former Molonglo River flats, which form the bed of the lake. In much of the area west of Commonwealth Avenue the base of the alluvium does not rise above R.L. 1800 feet; this deep alluvium encroaches on the northwestern corner of the Central Area near the southern abutment of Commonwealth Avenue Bridge.

The level of the groundwater in the area has been under observation since the lake filled. Northwest of the Acton Fault, the basements of buildings will probably be at about groundwater level, and foundations will be below groundwater levels. South of the Acton Fault, much of the ground surface is at a higher elevation; there the groundwater will be at greater depths, and should not be encountered except in very deep basements and foundations.

CAPITAL HILL

Capital Hill is rounded in profile and not far from circular in plan; it rises about 150 feet above the general level of the highway, Commonwealth Avenue, that runs south from Lake Burley Griffin and Canberra City. Capital Hill is separated by topographic saddles from the smaller Camp Hill in the northeast, from hills comparable to it in height in the northwest and west, and from a rounded ridge that runs south-southeast towards Red Hill. The surface contours of Capital Hill have been altered in a minor way by quarrying at the crest and by some filling of a valley on the northwest during the construction and widening of State Circle.

The bedrock in Capital Hill consists of Lower Ordovician Black Mountain Sandstone overlain unconformably by Lower Silurian Camp Hill Sandstone and State Circle Shale. A major fault, the Deakin Fault, passes through the southwestern slope of the hill, and a large branch fault, the "East" Fault, passes through the western slope. Southwest of the Deakin Fault, the bedrock consists of Upper Silurian volcanic rocks.

Black Mountain Sandstone occupies nearly all of Capital Hill east of the "East" Fault. Camp Hill Sandstone covers it in the north and east and extends as a narrow tongue from Brisbane Avenue to the crest of the hill. The segment of Capital Hill west of the "East" Fault and north of the Deakin Fault consists of State Circle Shale. The hardest rock, and the most resistant to weathering, is the Black Mountain Sandstone. The Camp Hill sandstone was deposited on an eroded and uneven surface of Ordovician rock (the Black Mountain Sandstone); it is irregularly folded and at numerous localities has been subjected to fracturing that ranges in intensity from close jointing to crushing and brecciation. It is weathered to considerable depths, probably down to its base. The thickness of the Camp Hill Sandstone generally increases towards the east; however, the eroded surface of Black Mountain Sandstone below it rises and falls in small hills and valleys which causes local reversals in the eastward thickening. A geological interpretation of the results of the seismic survey by Polak & Wainwright (1965) suggests that along the proposed route of a tunnel following a radial line towards Brisbane Avenue, the thickness ranges from zero at the boundary with the Ordovician to 50 feet at the intersection with a proposed ring road, and a maximum of 100 feet at a locality 200 feet westwards towards the crest.

The State Circle Shale consists mainly of laminated shale and bedded mudstone or claystone. Probably it has been subjected to folding and compression against the Ordovician basement rocks, but unlike the Camp Hill Sandstone, the resulting strain has had a much larger component of plastic deformation than of brittle fracture. The permeability is probably low throughout most of the State Circle Shale, and the depth of weathering much shallower than in the Camp Hill Sandstone.

The volcanic rocks in the southwest tend to weather deeply but irregularly. Decomposed and weathered rock in some places contains residual boulders of hard, fresh bedrock. Moderately weathered volcanic rocks which are capable of supporting moderate to heavy loadings commonly occur at fairly shallow depths.

The seismic timer survey indicates that the slopes of Capital Hill are covered by soil that ranges in thickness from 3 to 13 feet, and is commonly about 5 feet thick. The thickest deposits probably consist of angular fragments and other products of rock weathering that have gravitated down the slopes.

Table 1 gives the estimated depths at which the weathered bedrock has appreciable strength, such that, on the one hand, foundations would support moderate loadings, and on the other hand, some blasting would be necessary if it were to be excavated. The estimates are based on the results obtained with the seismic refraction investigation using the single channel seismic timer. At most localities this equipment did not yield information on changes in the hardness of the bedrock below a depth of about 20 feet.

TABLE 1.

Estimated depths at which some blasting would probably be necessary to excavate Bedrock.

Bedrock	Range of Depths in feet *	Remarks
Black Mountain Sandstone	5 to 11 (excluding Average 9 (anomalous (depths as in "Remarks"	Two traverses show depths of 15 to 20 feet, average 19. Probably not appreciably affected by the faults
Camp Hill Sandstone	Probably can be excavated to base without blasting	
State Circle Shale	10 to 20, average 15 Locally 1.5 to 8 Average 5.	The State Circle Shale is deeply weathered in a narrow zone adjacent to the Deakin Fault (Zone about 25 feet wide) and the "East" Fault (probably about the same width)
Volcanic rocks	5 to 15; average 8 Irregular weathering profile.	Jointed at contact with fault, but not greatly weathered.

* Includes the soil above the weathered bedrock.

GROUNDWATER

Since the area can be readily drained, and both fresh and weathered rock have low permeability, no difficulties are expected with groundwater.

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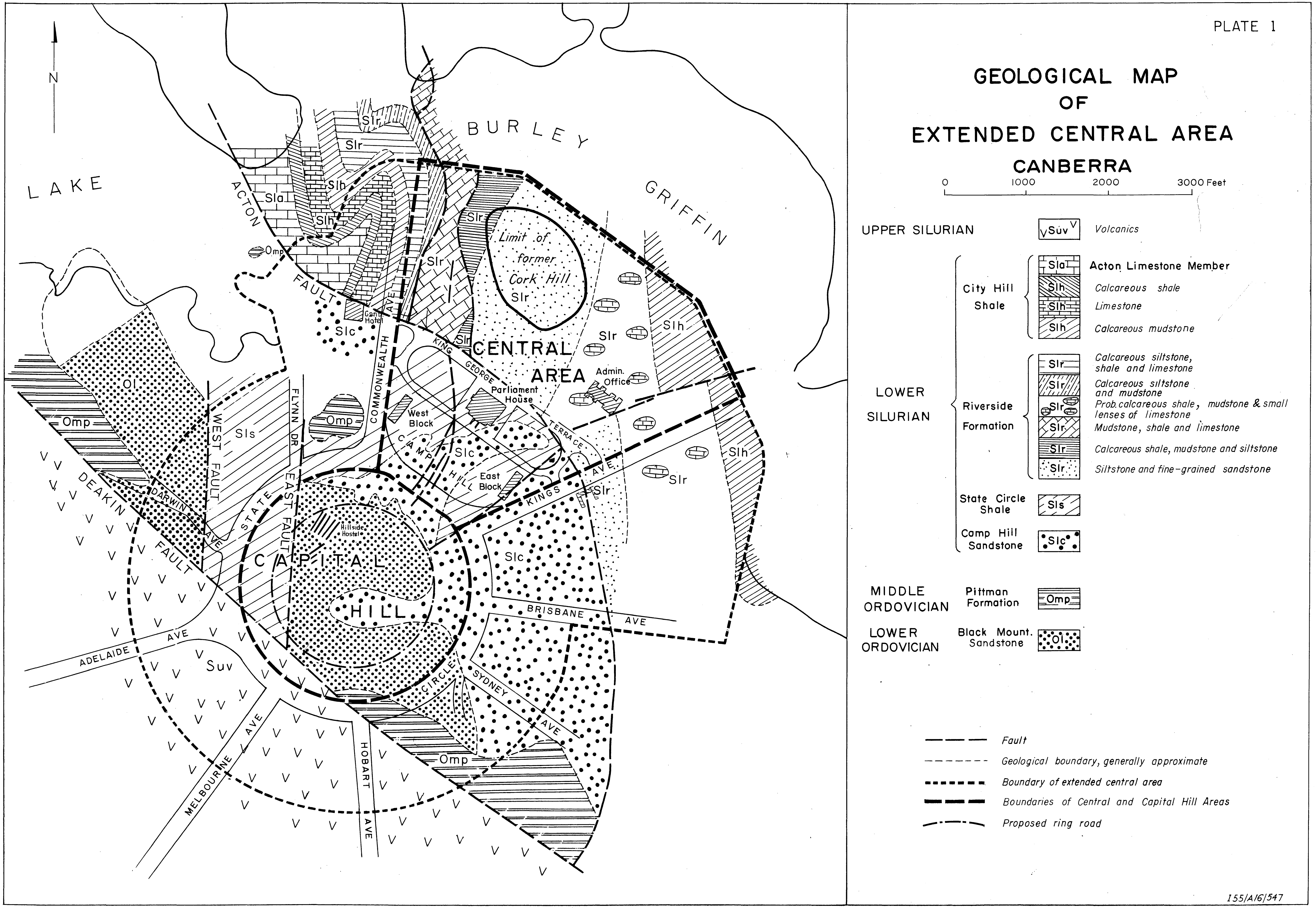

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