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GEOLOGY OF THE SPRINGTON-CAMBRAI AREA

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GEOLOGY OF THE SPRINGTON-CAMBRAI AREA

SUMMARY

During 1951 some geological mapping was carried out in the Springton Cambrai area. This report deals with the chief geological features observed, with special emphasis on structure, stratigraphy and metamorphism.

CONTENTS

GEOLOGY OF THE SPRINGTON - CAMBRAI AREA

INTRODUCTION :

During 1951 some geological mapping was undertaken in a part of the East Mount Lofty Ranges, about 40 miles E. N.E. of Adelaide. The area involved comprises about 45 square miles on the Cambrai one - mile military sheet, and is bounded by the following grid coordinates

2.05	- 2.26	East - West
7.11	- 7.18	North - South

Geological mapping was accomplished with the aid of aerial photographs (average scale of 4.1" ≈ 1 mile), the information was plotted directly on to the photos, and later transferred to a field sheet. Emphasis has been placed on structure and stratigraphy, rather than a detailed petrological study.

Similar mapping has been carried out by S. Kaewbaidhoon to the South, and to the North by R. C. Rowley and J. E. Harms. The areas adjoin. Although the report deals primarily with the writer's own area, it has been found necessary to refer to results obtained by these Honours Students, especially in the elucidation of geological structures, and stratigraphical successions.

PREVIOUS WORK :

The only previous work carried out in the area was that of P. S. Hossfeld in 1926. His contribution was in the form of a reconnaissance survey only, and the present detailed mapping has not borne out some of Hossfeld's conclusions, especially in regard to the structural picture. His regional interpretation, however, is quite sound.

TOPOGRAPHY :

The Eastern part of the area is occupied by the Murray Plains which are seperated from the ranges by a faitly steep fault scarp. The far Eastern side of the ranges is quite steep and rugged, the River Marne in particular, having in places, cut out a well defined gorge. This region of steep contour gradients persists for a width of about four to five miles, whence it gives way to undulating hills with a few sharp isolated peaks. The influence of geology on topography is well shown by the Keynes Gap sandstones which are responsibàà for the development of a well defined ridge about 12 miles in length. The average height of the ranges is about 1200' with a maximum of 1354' at Whites Trig.

STRATIGRAPHY & ROCK TYPES :

The sedimentary rocks met with in the area habe been divided up into the following horizons

TERTIARY & RECENT	Alluvium and Travertine Gravels and leached cappings
KANMANTOO SERIES	Pine Hut Quartzites Somme R. Micaceous Quartzites Saunders Ck. Marbles and Schists Keynes Gap Sandstones Eden Valley Mica Schists
	Granitised Sediments

TERTIARY - RECENT:

There is a marked deve̶lopment of recent sediments on the Murray plains, included in these are gravels, sands, and travertine limestone. About 1 mile east of Springton an iron rich lateritic capping has been found. It occupies the top of a ridge about ½ a mile in length and consists essentially of leached micaceous material with much haematite and limonite. In places it strongly resembles a gossan but there is no development of box-work to indicat the former presence of sulphide minerals. The heigth of this leached capping is 1300' which may represent the elevation of the old tertiary peneplain. This figure, however, does not agree with similar rocks outcropping to the south, some of these having elevatio of 1600'.

KANMANTOO SERIES :

Pine Hut Quartzites - The Pine Hut quartzites are the youngest beds of the Kanmantoo series as mapped in the field. Although they do not outcrop in the writer's own area, being typically developed along the Pine Hut Rd. to the north, these rocks have been included for the sake of completeness. They are hard dense quartzites consisting of essentially of quartz with some micaceous minerals giving the specimen a somewhat banded appearance. Owing to folding it is not possible to determine their thickness.

SOMme R. Micaceous Quartzites - These beds are stratigraphically belos the Pine Hut quartzites and they outcrop typically along the Marne and Somme Rivers. They contain much biotite, in places grading into sandy mica schists. When seen under the microscope quartz is the predominating mineral, being in the form of round subhedral grains. All the lathes have been orientated along the direction of schistosity. Felspar and apatite are accessory minerals while most specimens also show scapolite, in fact scapolitization is of such widespread occurrence in the eastern part of the area, that nearly all rock types, especially marbles, show evidence of having been altered in varying degrees. The subject will be dealt with more fully under metamorphism.

The Somme R. micaceous quartzites are fairly competent beds, and where they have been folded (along the Marne R.) the folds are of the open symmetrical type. The more schistose varities differ in that they are relatively incompetent, and appear to have yielded more by flowage. Again, the thickness of these beds is uncertain, being complicated by folding.

Saunders Creek Marbles and Schists: This horizon has furnished a basis for the interpretation of regional structures and is thus very important. It consists of dense pale coloured marbles interbedded with sandy micaceous schists and quartzites, and containing also a few narrow bands of scapolite - diopside rock. The most prominent rock types are marbles, they are well developed just south of the Marne, about 1½ miles before that river reaches the Murray plains. They consist essentially of recrystallized calcium carbonate with varying quantities of green diopside and scapolite. In places the latter mineral predominates. The marbles have been intensely folded, of the ptygmatic type, and in all places have behaved very incompetently and yielded by flowage. This folding has made it impossible to interpret structures, but it is considered that each limestone horizon is a seperate one, folded in itself, and not one bed which has been tightly folded. The question, however, will be discussed more fully under structure. In contrast the interbedded schists and quartzites have behaved in competently, in fact they are little folded. The marbles are also characterized by their lenticular form i.e. the beds have not been deposited as one continuous horizon but as a series of lenticular beds, varying in length and width over a wide range. This folding and lensing have combined to give a somewhat complex outcrop pattern, but one which can, nevertheless, be explained. The inter-bedded schists consist almost entirely of quartz and biotite and vary from very micaceous to sandy in appearance. As already stated, they differ from the marbles in that they show little evidence of folding. Several lenses of dense hard quartzite, finding topographic expression in ridges and sharp peaks are also interbedded with the schists.

Other rock types of petrological interest have been mapped in this horizon, amongst which is a narrow band of tremolite - diopside - quartz gneiss (outcrops in the Marne River), some epidote schist, and several well developed bands of scapolite- diopsiderock. The latter occurs in lenses up to 15' in thickness, but which cannot be followed for any great distance along the strike. The rock is made up mostly of scapolite with diopside, calcite, and quartz, and has a characteristic appearance on weathering. Thickness of the Saunders Ck. marbles and schists is difficult to determine, but is of the order of 5,000'.

Keynes Gap sandstones - The Keynes Gap sandstones are a massive series of sandstones and quartzites stratigraphically below the Saunders Ck. marbles and schists. They are responsible for the development of a well defined series of ridges, the latter being one of the most prominent topographic forms in the area. These sandstones have in places, been metamorphosed to quartzites and even mica schists, but quartz is the predominating mineral. As we go South, however, the rocks become more and more micaceous, this is possibly indicative of greater metamorphism to the South, or perhaps a facies change. Again, in places the rocks have been granitized, i.e. recrystallization has taken place with the development of granites and granite gneisses. This zone of granitization is not very widespread, and appears to have no structural or stratigraphic control. It is estimated that the Keynes Gap sandstones, typically developed at Keynes Gap, are approximately 5,000' in thickness. They show no evidence of folding, and in places are so massive that bedding planes are difficult to determine.

Eden Valley Mica Schists - These rocks are the oldest members of the Kanmantoo series as mapped in the area. They differ from the rocks previously described in that they are more highly metamorphosed, consisting mainly of folded biotite schists which have been altered to biotite gneisses, quartzo-felspathic rocks and granites (migmatites). An interesting feature of the granitization is that it appears to be structurally controlled, in one place there is a zone of quartzo-felspathic rock along the crest of an anticline, in another a marked development of granites and granite gneisses occurs along a synclinal trough. This is well shown just south of the Marne R. near the Eden Valley Springton Rd.

The mica schists when seen under the microscope consist of biotite, muscovite, chlorite, quartz, and plagioclase. When granitization is well developed the schistosity grades into a gneissic structure. These latter rock types are indicative of intrusion of granitic material along the bedding planes, a type of lit-par-lit injection. Although the biotite schists are remarkably uniform in character over a wide range, there are other rock types developed. Near Springton is found a thin band of hard pure zuartzite, which seems to be folded more than the enclosing schists. It has been quarried for road metal. Other smaller bands of quartzite have also been recorded but appear to be the result of facies changes only. The granitized zone occuping an anticlinal position i.e. a quartz felspar rock, appears to be the result of reclystallization of an arenaceous sediment, whereas the biotite schists are obviously of argillaceous origin. It is difficult to determine the thickness of the Eden Valley schists.

AGE O F THE KANMANTOO SERIES:

There is much speculation as to the age of the Kanmantoo series, that series of metamorphic rocks accupying the Eastern half of the Mt. Lofty Ranges. R. C. Sprigg of the S. A. Mines Department considers that they are Ordovician in age and that they are seperated from the Adelaide System on the western side of the ranges, by a faulted unconformity i.e. the Ordovician sediments have been down-faulted relative to the Proterozoic.

It was not possible to study the fault contact between these two series of rocks as it occurs a few miles west of the area mapped, but there seems to be little evidence in favour of the rocks being Ordovician in age. Moreover, it is considered that the Kanmantoo series are of the same age as the Adelaide system, i.e. Proterozoic. Evidence in favour of such a view -

1. The Kanmantoo series are more highly metamorphosed than

the Adelaide System, and if anything should be regarded as being Pre rather than Post Proterozoic.

2. Hossfeld has reported the finding of tillite in sections 370, 380, Hundred of Dutton (just north of Truro), and he considres that this glacial horizon when traced further south becomes part of the Kanmantoo series. There seems to be no reason why this should not be correct, and if we assume that the glaciation is proterozoic in age, then the Kanmantoo series also belong to that period.

3. There is no fossil evidence which would indicate that the series were Ordovician. This, however, is not conclusive as fossil evidence could have been destroyed by metamorphism, but it is considered that if the series were fossiliferous some trace of them would have been found.

IGNEOUS ACTIVITY

There is comparitively little evidence of igneous activity within the area as most of the granites are considered to be, not magmatic but of migmatic origin. In some cases, however, this is purely a matter of interpretation.

GRANITES - It is considered that t here is evidence of only one true magmatic granite. It is a small intrusion, located about ½ mile North of the Marne R. just near the plains, and is located in schists of the Saunders Ck. horizon. In the hand specimen, the constituent minerals are quartz, felspar, biotite and pyroxene.

PEGMATITES - Numerous pegmatite dykes have been located in almost every stratigraphic horizon, but in particular the Saunders Ck. marbles and schists. The pegmatites are typically composed of quartz, felspar, and in many cases tourmaline. They are rarely coarse grain but more of a granite pegmatite, often with a tendency towards graphic structure. The majority of these dykes are cross-cutting, up to 300' in length, but usually of narrow width. They appear to be associated with mineralization at the Kanappa Copper Mine, and also with granitization, and it seems possible that intrusion by pegmatites may represent the end phase or possibly an intrusive phase of granitization.

DOLERITES - Although numerous dolerite dykes are to be found further north, only one has been located in the writer's own area, i. e. on the banks of the Marne R. It has been extensively sheared and is obviously post Kanmantoo and pre-folding in age. The dyke is about 10' in width, and is intrusive into schists of the Saunders Ck. series. Under the microscope the predominating minerals are hornblende, biotite, quartz, plagioclase and scapolite. Scapolitization of the dolerites appears to be of wide-spread occurrence, being found in most parts of the State. Further north in R.C.Rowley's area the dolerites appear to be structurally controlled, being oriented along a meridional direction of shearing. These dolerites are, however, post folding in age.

QUARTZ AND IRONBLOWS - Throughout the area numerous small quartz blows occur. They appear to represent a differentrated phase of pegmatite intrusion. Quartz-iron blows also exist but they will be discussed under mineralization.

METAMORPHISM:

Under this heading are considered regional metamorphism, Granitization, scapolitization and mineralization.

REGIONAL METAMORPHISM : The process of regiional metamorphism has been operative to produce quartzites, micaceous quartzites, biotite schists and marbles. The quartzites and schists were originally impure sandy sediments which have been silicified with micaceous minerals developing along the direction of schistosity (corresponds to the original bedding planes). Marbles have resulted from the alteration of a limestone, ranging from pure to very impure $CaCO_3$. The impure limestones have given way to a greenish diopside marble, and in extreme cases tremolite has developed, while the purer varieties have merely recrystallized.

GRANITISATION : This may be regarded as the extreme form of metamorphism, accompanied by much metasomatic replacement. As stated, the granitization is of three types -

1. Granitization of the Keyne's Gap sandstones
2. Granitization of an arenaceous sediment within the Eden Valley schists
3. Granitization of the Eden Valley schists

The Keyne's Gap sandstones appear to have been merely recrystallized with the addition of a little granitic material. The hand specimen resembles a typical granite, being made up of quartz, orthoclase, plagioclase, biotite and chlorite. Outcropping boulders show tor structure, quite typical of a magmatic granite. It is considered that the original rock was an impure sandstone, but the reason for distribution of granitized material within the sandstone horizon is obscure, as there is no evidence of any structural control.

The second type of granitization, resulting in the formation of a white coloured quartz felspar rock is definitely controlled by structure. The granitized belt is 1500' in width, and occupies the crest of a flat pitching anticline. Under the microscope the rock consists of quartz, felspar, with small amounts of diopside, epidote and scapolite. The original rock is thought to be a fairly pure sandstone, some specimens showing traces of original bedding planes.

Granitization of the Eden Valley biotite schists is well shown 3 miles North of Springton. Every gradation between biotite schist and granite can be mapped in the field, especially granite gneiss, which appears to have been formed by the injection of granitic material along the planes of schistosity. Where this injected material is of sufficient width, and where it is accompanied by metasomatic replacement, then granites develop. The main belt of granitization is structurally controlled, occupying a synclinal position in the biotite schists. This belt is about 3000' in width. In the hand specimen, and under the microscope, the rocks are indistinguishable from magmatic granites, as there is no trace left of any original bedding or schistosity. Their gradation into granite gneisses of obvious sedimentary origin, their structural relation to the biotite schists, and the development of much chlorite and epidote, are all indicative of granitisation.

SCAPOLITIZATION : Scapolitization is of widespread occurrence especially in the Eastern half of the area where it is associated with the diopside marbles, often in the form of large well developed crystals. The mechanics of scapolitization are but vaguely known, and for the mineral to develop in schists, quartzites, and micaceous quartzites, much additional chlorine would be required. The gaseous entry of chlorine ions seems to be a possible explanation, but it is difficult to conceive how scapolite can develop in rocks containing little or no felspar, i.e. diopside marbles. An interesting feature is that maximum development of scapolite occurs at and near the Kanappa copper mine, there may possibly be some relation between scapolitization and mineralization, but much more information is required.

MINERALIZATION : At the Rhine Valley silver lead mine there is a minor development of galena and siderite within the marbles and schists. Mineralization occurs along a line of faulting, but is of no economic importance. A quartz-iron blow containing a little gold was also located, it consists of a small fissure vein about 12" in thickness, and dipping parallel to the bedding. At the surface the vein has spread out to form a gossan containing much haematite and limonite. This vein is in mica schist, but very close to a small lense of marble.

The most notable mineralization in the area occurs at the Kanappa copper mine. It has been accompanied by much scapolitization, pegmatite intrusion, and extreme metamorphism, the schists having been altered to garnet sillimanite gneiss. The country rocks are marbles and schists which have been extensively folded, the former having yielded by flowage, while the schists have behaved more competently. It is thought that this difference in competency was responsible for much fracturing of the rocks, and has provided a loci for the deposition of chalcopyrite, pyrite, and a little gold. The relation between scapolitization, extreme metamorphism, and mineralization appears to be more than a coincidence. Most of the chalcopyrite appears to have formed within the schists and gneisses, but some developmental work has been carried out in marble. Numerous pegmatite dykes cut through the underground workings. The control of mineralization, therefore, appears to be structural, i.e. folding was responsible for a fracturing of the beds which were later replaced by ore solutions. Similar conditions appear to exist elsewhere, but no mineralization has resulted.

STRUCTURE

In the Eastern half of the area the predominating structure is a north pitching syncline, the central core of which is made up of the Somme R. micaceous quartzites. Below are the Saunders Ck. marbles and schists occupying both the east and west limbs of the fold. The Keynes Gap sandstones, however, only occupy the western limb, the eastern portion being down faulted beneath the Tertiary on the Murray Plains. The nose of this syncline as developed in Saunders Ck. (Kaewbaidhoon's area) has been extensively sheared, and drawn out into a thin wedge shaped structure, while along the Marne R. the nose of the fold has been severely crumpled and distorted, producing many anomalous features. Elsewhere the nose is quite regular and open (pitching north at about 25°) and the axial line can be easily traced for many miles. Due to this prevailing structure, the regional dip of the sediments in the western half is to the east, any variations being due to some minor folding within the Eden Valley schists.

About 3 miles east of Springton is found the crest of a flat pitching anticline, and occupied by a belt of granitized material, while north of Springton another belt of granitization marks the position of a synclinal trough. The Springton quartzites also show evidence of tight folding, but the enclosing schists do not appear to have suffered the same deformation as they dip quite regularly. The above folds, therefore, are but minor crenulations on a broad syncline whose eastern limb has been largely cut off by faulting.

Within the Saunders Ck. marbles and schists much folding has taken place, the marbles in particular, forming very complex structures. To the east of this main syncline is a closed basin structure separated from the syncline by a zone of shearing and faulting. The outlines of this closed basin are marked by a marble horizon which, in itself, is tightly folded. Further east is another thick bed of marble, again highly contorted, but this is thought to be a different band unrelated to the adjacent basin structure. The enclosing schists have also been folded but the regional dip of these rocks is to the west, especially nearing the Murray plains.

The Somme R. micaceous quartzites show excellent drag folding especially where those sediments adjoin the sheared and faulted contact with the marbles.

FAULTING : Evidence of faulting is confined almost entirely to the micaceous quartzites and the marbles and schists. Faulting has taken place in both Proterozoic and Tertiary times, displacement in the latter period often occuring along old Proterozoic fault planes. The most prominent fault is that which occurs on the eastern boundary of the ranges. It is responsible for the downfaulting of much of the eastern limb of the syncline, and at the moment is represented by a fairly steep fault scarp. Presumably this displacement, which occured in Tertiary times, followed the line of an old Pre Cambrian fault as its position appears to be a reflection of the path traced out by other faults of definite Proterozoic age. As we go north along the Scarp there is a periodic displacement of the fault to the right, that is, at each point the line of faulting has been displaced a distance to the east. Relating this to the strain ellipsoid, the main line of faulting appears to represent a tension direction, while the meridional displacement corresponds to a direction of shearing. Displacement of the Proterozoic sediments along this fault is of the order of 1000' but is not known accurately.

The other important fault occurs adjacent to the band of marbles - it represents a faulted contact between marbles and the enclosing schists. Displacement is as follows - the eastern block has moved up relative to the western but the actual vertical movement is not known, a small lateral movement to the north also occured. It is obvious from the map that there is insufficient room for the sediments on the western limb of the syncline to turn around and form an eastern limb, and a fault appears to be the only possible explanation of such a structure. Although this fault cannot be seen in the field, strong evidence for its existence is shown just south of the Marne R. where Somme R. micaceous quartzites striking east-west abut against a lense of marble striking north-south. Again, there is lead-zinc mineralization at this point, and this is considered to be further evidence of faulting as to the north Galena has been found along a definite fault line. This place of faulting continues north for many miles, and just near the Marne R. it leaves the marbles and schists and is developed within the micaceous quartites. This faulting has been accompanied by much shearing during which the marbles have been tightly folded and compressed and have yielded by flowage.

It is considered that the structure has been formed by east-west compression with later lateral movement from the south (responsible for minor cross folding). The axial planes of the fold run approximately north-south with the main lines of faulting also being in that direction. Some minor shearing, with very little displacement occurs at a bearing of approximately 45°, and this corresponds to the shear direction. Most of this faulting took place during Proterozoic times with a renewal of displacement in the Tertiary.

It is considered that the complex structures formed within the marbles and schists are due solely to the difference in competency of these two rock types. The schists have been able to withstand compressive forces, and have formed fairly open folds, whereas the marbles have behaved as a viscous liquid, giving rise to all types of "impossible" structures, in many places giving the impression that the schists and marbles were unconformable with one another, but this is definitely not the case.

GEOLOGIC HISTORY

PRE-CAMBRIAN

1. Deposition of the Kanmantoo series in Pre-Cambrian times. The sediments were mainly argillaceous with a few of an arenaceous or

calcareous character.

2. Intrusion of basic igneous rocks.

3. Elevation and folding of the Kanmantoo series accompanied by faulting.

4. Metamorphism of the folded sediments culminating in granitization and mineralization.

5. Intrusion of basic igneous rocks and pegmatites.

6. Scapolitization.

TERTIARY -

.1. Formation of a flat peneplain during Tertiary times. Erosion of the Kanmantoo series.

2. Much fracturing and faulting during the Pleistocene, resulting in the elevation o f the Mount Lofty Ranges, and formation of the Murray plains.

3. Development of streams showing their superimposed character, e.g. the River Marne shows evidence of old ox-bows.

4. Further movement of the fault blocks, the movement in many cases being along the same direction and fault planes as the Pre-Cambrian faults.

5. Erosion in recent times with deposition of gravels, clays, sand and travertine.

ECONOMIC GEOLOGY

Very few minerals or rocks of economic importance are to be found in the area. Chief occurences are

COPPER - Copper mineralization, as stated, is found at the Kanappa copper mine where chalcopyrite occurs as impregnations in mica schist.

A production of about 100 tons has been recorded, but there is little likelihood of the mine ever being re-opened.

SILVER-LEAD - The Rhine Valley silver-lead mine is of interest only in that mineralization seems to be structurally controlled, the gallena having developed along a line of faulting.

GOLD - A narrow quartz-pyrite-gold fissure vein occuring in the Saunders Creek marbles and schists was responsible for a shaft being sunk, but little gold was ever recovered. There is a small gossan.

ASBESTOS - A small amount of asbestos was found in a marble horizon and probably represents the metamorphism of an impure limestone. It is of no economic importance.

QUARTZITE - Large amounts of quartzite have been quarried for use as road metal, the present supply coming from a quarry about 2½ miles N.W. of Springton. This narrow band of quartzite is part of the Eden Valley mica schists horizon, and has been extensively folded.

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