CLAYS DERIVED FROM THE LOWER DWYKA SHALES OCCURRING IN THE VICINITY OF GRAHAMSTOWN.

by

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THESIS.

Clays derived from the Lower Dwyka Shales, occurring in the vicinity of Grahamstown.

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The Lower Dwyka Shales in South Africa occur south of latitude 32^{o}; resting conformably upon the Witteberg quartzites, which extend as coastal mountain ranges along the length of the South Coast. The shales, being less resistant to weathering than the quartzites below, and the Dwyka Tillite immediately above, are consequently found in valleys between these two formations.

In one of these valleys Grahamstown is situated; where the Lower Dwyka Shales have been eroded by the various rivulets forming the source of the Blaauwkrantz River.

A geological map of the country round Grahamstown was prepared in some detail, showing all the various rock formations occurring in the area, the full extent of the Lower Dwyka Shales being mapped with the Dwyka Tillite and the Witteberg Quartzite along its margins. The map includes an area of about six miles by three, with the Cathedral spire occupying an approximately central position, and is prepared on a scale of 5.65 inches to one mile. Traversing was done by means of prismatic compass and pacing.

Topography.

The country to the north of Grahamstown consists of a tertiary peneplain, known as the Flats which is covered to a large extent by "surface quartzite", a deposit averaging about ten feet in thickness, and for which the name "silcrete" has been proposed by Lamplugh. This covering of surface quartzite conceals to a large extent the Dwyka Tillite underneath it, the edge of which forms the escarpment to the north

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of the City. The hills along this escarpment, such as West Hill, Sugar-loaf Hill, Makana's Kop, are merely projecting butts, composed of Dwyka Tillite and capped with Surface Quartzites.

South of the City runs a high ridge, composed of folded Witteberg Quartzites, whose strike is in a fairly constant southeast - northwest direction, and coincides nearly with the principal axis of folding. The difference is due to the fact that the 'en echelon' arrangement of the folds in the Witteberg is here reproduced on a small scale.

Except for Municipal Plantations, this ridge is treeless and bare. It has been deeply cut into on both sides by rivulets forming the source of the Kowie and Blaauwkrantz Rivers, making the country rugged and wild in appearance, and in striking contrast to the gently undulating peneplain two miles to the north.

Grahamstown lies in a deep hollow between the southern edge of the peneplain and the Witteberg Ridge. The valley commences at the Brickfields to the west then widens out considerably and finally narrows down again in Belmont Valley, along which the Blaauwkrantz River runs. The Lower Dwyka Shales occupy the greater part of the valley.

At the head of the valley the Surface Quartzite Plain continues right up to the base of the Witteberg ridge, and this section of ground forms part of the watershed between the Kowie and Bushman's Rivers. The Blaaukrantz River, which is a tributary of the Kowie River, has its source here, and flows in a southeasterly direction down the valley, being joined en route by numerous, but usually dry stream beds from the edge of the Flats and the Witteberg hills.

Geology.

The Witteberg Quartzites, the lowest member of the Series appearing on the map, are intensely hard and massive. They consist mostly of a fine-grained, current-bedded rock of a greyish-white colour when unweathered, composed very largely of pure quartz. When weathered the colour changes to yellow, and brown.

The Quartzites are intensely folded; a remarkable feature being that little or no fracturing has been produced, although a tremendous amount of strain must have been imposed.

The main axis of folding runs in a north-westerly direction, the fold in general being a single steep anticline. From Stones Hill westwards, however, the anticline divides into two, one large one which continues along the Mountain Drive and further beyond, and a smaller one which pitches to the west, and ultimately disappears beneath the Surface Quartzite, south of the Brickfields.

The trough between these two anticlines is filled in with Lower Dwyka Shales, which extend as a narrow strip up towards Mayor's seat. The exact extent eastwards is unknown as there are no exposures, but it is unlikely, from considerations of the dip of the Witteberg taken in the vicinity, that the Shales extend beyond the Mountain Drive Road.

In addition to the two large anticlines, there are numerous small folds, and almost every type of folding has been reproduced. In the process of folding the rock has in places become foliated, the foliation being parallel to the bedding planes, and along which a certain amount of movement seems to have taken place, as one frequently finds thin layers of a sandy, friable material. Flakes of a micaceous mineral are also developed along the planes of foliation, and

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where this is extensive, as in certain of the Witteberg shalebands, the rock assumes a distinctly schistose character.

Mr. J. Adams, A.R.C.A., mentions in an article in the South African Journal of Industries, p. 770, May, 1918, that Prof. Schwarz informed him that he obtained specimens of absolutely pure Kaolin in the upper Witteberg rocks.

At the top of Hill street, where the road makes an "S" bend, the Witteberg is dipping steeply north; further down the slope along the streambed the dip becomes vertical, and when the margin of the Shales is reached, the latter will be found to be dipping under the Quartzites, showing an overfold. This overfold is nowhere else shown in the various exposures of the margin examined, although the dip is very steep everywhere, especially in the Belmont Valley, where it varies from 75° North to vertical.

On some of the bare slopes of the hills near Stones Hill the folding of the Witteberg can be distinctly traced, with patches of Dwyka Shales incorporated by the folds.

The Lower Dwyka Shales.

These lie conformably on the Witteberg, and occur at the base of the northern slopes of the ridge. When unweathered the Shales are generally bluish-grey in colour. Variations in colour are observed near the margin of the Dwyka Tillite. At the surface, however, the shales near the Witteberg margin have been weathered to a pure white clay, which has a soapy feel. The shales, even when weathered, show distinct bedding planes, which are remarkably well developed and even. The clay is obviously residual, resulting from the accumulation in situ of the weathered shale.

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Outcrop of White Clay. ~~Foot~~ Top of Somerset Street.

The margin between the shales and the Witteberg is very well shown round about the southern end of Somerset Street. There are numerous exposures on the surface and in cuttings and furrows on the side of the hill. A large scale map of this vicinity was prepared and the succession of beds worked out in detail.

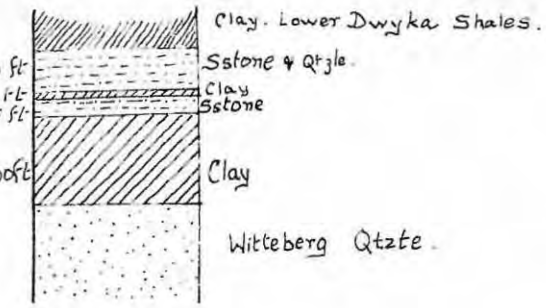
Approaching the margin from the Witteberg side, proximity to the margin is indicated by the Witteberg ~~side~~, becoming extremely coarse-grained, in fact it becomes almost conglomeratic in nature, about ten feet away from the shales.

This coarse-grained bed is only a few feet in thickness, but remarkably persistent, use being made of this horizon in mapping the margin of the shales. As the shales are approached, the grain becomes finer and the rock becomes more of a sandstone until the actual margin is reached, where, within a distance of six inches, the rock grades from a sandstone into a sandy clay and then a clay with practically no grit.

The beds here dip at 45° to the northeast, the strike being 312°, but owing to the presence of numerous small folds the dip is not anything like constant. This fact also hampers the calculation of the thickness of the various beds encountered. The thickness of the deposits given are calculated on the basis of an average dip of 45°N.E.

After leaving the margin and proceeding in the direction of the dip, a bed of white clay is encountered, which is about 200 feet thick and quite homogeneous as to texture. The clay is the weathered product of a greyish splintery shale. Above the clay band lies a bed of coarse-grained, markedly falsebedded sandstone, dipping at 45°N.E. The bed is about 15 feet thick, at the top of which there is a bed of pure white clay, slightly gritty to the touch.

Above this clay band more sandstone is encountered, which is soft, friable, foliated, and micaceous. This sandstone is about 80 feet thick; towards the middle it becomes more thickly bedded, the rock becomes hard and quartzitic and resembles very closely the Witteberg quartzite found near the margin. In its mode of weathering, jointing, together with the occurrence of small specks of micaceous mineral, and its general appearance, the rock might very reasonably be included as a member of the Witteberg Series.



Near the top of the band of sandstone, the latter is interbedded with sandy clay, and finally merges very gradually into pure white clay. Most of the sandstone is soft and friable and when rubbed between the fingers it leaves an extremely fine white powder, due to the clayey matrix in which the grains are embedded.

A curious feature was observed in the sandstone,

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where in one particular place the strike, otherwise fairly constant, had turned through a complete right angle, owing to the presence of a small steeply pitching anticline, in which the quartzite band was involved at the exposure. The axis of the fold was nearly at right angles to the general axis of folding.

Outcrops of shale between the sandstone and the margin of the tillite are extremely rare, owing to the covering of soil; the only large exposure is in the Brickfields, where the shale has been weathered to a depth of at least forty feet, still retaining its bedding planes very distinctly. The clays here dip uniformly at 65° north, and do not give any indications of folding.

The shales appear to be more or less homogeneous; only here and there does one encounter thin bands composed of lense-shaped patches of sandy material embedded in the clay.

The dip at the base of the shales in the Brickfields is 55° north; at the top the dip is 65° north; and taking 60° to be a fair average of the dip, the total thickness of the Lower Dwyka Shales, calculated on this basis, is found to be about 1,500 feet. In Belmont Valley, where the dip varies from 75° N. to vertical, a result is obtained for the thickness of the bed, also approximating 1,500 feet. Rogers[x] estimates the thickness of the shales to be about 1,000 feet, while [x]du Toit's estimate is considerably less.

The shales occur as a long strip, narrow in Belmont Valley, but gradually becoming broader through the city towards the Brickfields, and finally covering a large area in the western portion of the map. This large area represents the

shales/

x Rogers: Geological Structure of the Union, Union Survey 1925.

x du Toit: Geology of South Africa p.207 - 1926.

shales overlying the Witteberg where the minor anticlines disappears under the surface due to its westerly pitch. The gradual broadening of the outcrop is also due to the dip becoming shallower.

On the southern portion of Mr. C. Palmer's farm, "Fairholm", near the railway line, the shales fill a synclinal trough, which extends in a southeasterly direction through Mr. Nelson's farm and towards Mayor's Seat near the Mountain Drive. This strip of shale has been much altered, and is quite different in appearance from the shales in the Grahamstown valley. This alteration is due to pressure which has been exerted on the shales during their incorporation in the Witteberg folds.

Specimens of the shales obtained from a pit on Nelson's farm show a well developed slaty cleavage. In Belmont Valley near the Witteberg margin, the shale has become thinly laminated, and compacted to a certain extent. This renders it more resistant to weathering, and explains the absence of great deposits of clay in the Valley like those further north-west.

This compacted shale is usually bluish-grey in colour and contains pyrites. The slate from Nelson's farm is black but this is due to carbonaceous matter. There are several of these carbonaceous bands in the shales and clay near the top of the formation, but they are seldom more than a foot thick.

The shales have been weathered to a great depth around the brickfields and on the farms "Fairholm" and "Strowan". [x]Du Toit and [x]Haughton mention the fact that the Dwyka Tillite and Shales have been weathered to a depth of about forty feet,

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x Du Toit: Geology of S.A. p 364.
x Haughton: Union Survey, Cape Sheet No. 9.

but it is certainly much more. A borehole put down in the Brickfields, 395 feet deep, needed casing all the way down, although details about the core are unabtainable. The clay bank in the Brickfields is at present about forty feet high, and consists entirely of soft weathered material, the weathering probably continuing to a much lower level.

The clays encountered near the surface are nearly always pure white, and where there is no covering of soil, conspicuous white patches appear, as at the top of Somerset Street, in the Brickfields, and the farm "Fairholm".

Where the shales have been compressed and indurated, they weather into splintery fragments, and the streambeds passing over the shales are covered over with a gravelly deposit. These fragments ultimately disintegrate and form clayey soils.

The Dwyka Tillite.

Only one exposure showing the margin between the Lower Dwyka Shales and the Tillite was found on the area mapped. This exposure is in the railway cutting about a hundred yards west of the point where the Cradock Road crosses the railway line. The succession is clearly shown here and was carefully examined. Although the division between the shales and the Tillite is quite sharp, no trace of unconformity was observed. The whole exposure is weathered to a great extent but bedding planes are distinct, and it was found that at the margin the beds were dipping regularly at 50° north, the strike being 310°.

Close up to the margin the shales are much the same as elsewhere, the first difference to be noticed being a sandy layer, containing much clayey material, and about six inches thick. The sand then becomes coarse and gritty, grains

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of quartz and felspar becoming distinguishable, and after traversing about a foot of this material, pebbles and grains about the size of a pea are found. To the north of the margin, the pebbles increase rapidly in size; a boulder of granite one foot in diameter being found about five feet away. The rock here is richly studded with rounded pebbles, although boulders as large as the one mentioned are rare at this horizon. The first occurrence of pebbles may be taken as the base of the Tillite. The unweathered Tillite is of the dark blue, extremely hard southern type, with bedding planes very rarely identifiable.

The rock is jointed and cracked, the cracks running through matrix and boulders indiscriminately. The boulders cannot be removed from the matrix by means of a hammer only, except where the latter is weathered.

Most of the Tillite at the surface is weathered, the product being of a buff colour, but here and there on the hillsides white patches occur, where the Tillite has been weathered to a white clay.

The inclusions in the Tillite usually are more resistant to weathering than the matrix, and many good specimens of faceted and ice-scratched boulders may be picked up among the starch-like weathered fragments of the matrix.

The edge of the Tillite enters the Grahamstown valley just above the place where the margin in the railway cutting occurs. From here, although covered up with soil and alluvium, the margin presumably occurs along the south bank of the Blaauwkrantz River, and on the south slopes of the valley below the Mental Hospital.

The Surface Quartzite.

The Surface Quartzite is a deposit of tertiary age,

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formed in situ, and covers a large peneplained area in the Albany district.

North of Grahamstown, the country is known as the Racecourse Flats, and so level is it that Grahamstown possesses the finest natural aerodrome in South Africa.

View of Grahamstown showing surface Quartzite peneplain in the background.

The surface quartzite consists in part of a consolidated gravel, the cementing material being silica, sometimes containing a large percentage of iron, and is probably an analogue of laterite. The fresh surface is greyish white in colour, but the weathered is nearly black, due to the iron concentrated on the surface. The name "silcrete" has been proposed for it, in contrast to the ferruginous form "ferricrete".

The deposit is seldom more than ten feet thick, unbedded, with well developed joint planes. It is conglomeratic in texture, and includes large boulders, pebbles and sand derived from the underlying rocks.

North of the city it overlies the Dwyka Tillite on the farm "Fairholm" it covers the Lower Dwyka Shales; from there the plain extends southwards and meets the Witteberg ridge west of Nelson's farm. From there the surface quartzite level can be traced for some distance along the Mountain Drive ridge, where it is present as a narrow shelf.

The remains of another peneplain, also covered with silcrete, and 150 feet lower than the first can be traced along the Witteberg slope at the southern end of Somerset Street. It is identical in appearance with the higher level surface quartzite.

The base of the deposit is not sharply defined, as it merges gradually into the weathered material below it, becoming softer in depth.

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The section shown on the accompanying tracing is more or less typical of the area, and is made along an approximately north and south line which is drawn just east of the Brickfields.

The folding of the Witteberg has been generalised to a certain extent, the two major anticlines being shown, with the inclusion of Lower Dwyka Shales between them. It becomes evident at once that the shales here have been subject to far greater pressure during the folding than those further north, hence their difference in appearance.

The tertiary peneplain, with its deposit of surface quartzite is well-marked, and indicates that the tectonic features shown were developed long before tertiary times. The shales and Tillite, although dipping steeply north, are not contorted like the Witteberg.

The contours shown in the section were determined by means of an aneroid barometer, zero being taken as the bed of the Blaauwkrantz River, which represents the base-level of erosion locally. This point is about 1,800 feet above sea-level.

Clays.

As remarked previously, the Dwyka Tillite and the Lower Dwyka Shales have been weathered to a great depth, and this has resulted in the formation of large deposits of clay around Grahamstown. The Tillite clay differs from that derived from the shales, therefore these will be treated separately.

Clays derived from the Lower Dwyka Shales.

The shales have been extensively weathered everywhere, but more so in the western portion of the mapped area.

The claybank in the Brickfields was carefully examined where a dip section is exposed. It is at once apparent that there are several varieties of clay, judging by the various colours exhibited.

The beds dip uniformly north, with the strike at 312°. Further up the slope, where a few trenches have been cut above the railway line, the beds dip at 65° north, which is somewhat steeper than in the brickfields cutting or quarry.

The different clays occurring in the bank have been tested by Mr. Scarratt, the Manager of the brickfields, and much valuable information as to the respective characteristics and merits of the clays was obtained from him.

The topmost bed of clay is almost pure white, becoming slightly tinged with yellow in depth. This clay is very finegrained and yields a large proportion of colloidal matter. It is very highly plastic, and is used in the manufacture of earthenware drainpipes.

An analysis of clay from this bed was made with a view to finding whether there were any substances present which would have a deleterious effect on articles manufactured from the clay, but except for a small percentage of iron, nothing objectionable was found. This bed of clay is known as No. 2 Clay.

The next bed of clay below the white, is a sandy, buff-coloured clay, used extensively for brick-making. It contains a band of black, carbonaceous clay about a foot thick, but which burns nearly white. Its presence in the clay for brickmaking is not objected to.

Below this there appears a thick deposit of clay which, when slightly damp, is quite a bright purple. It contains an appreciable quantity of manganese, and is highly plastic. The burnt product from this clay is a greyish-purple in colour.

Underneath the purple bed, the clay is a yellowish brown in colour. It is somewhat harder than the clays above, not being weathered to the same extent. When placed in water for a while the fragments become soft and disintegrate easily. This bed of clay is quarried and left exposed to the action of the atmosphere for a while before being ground and pugged. This clay, however, known as No. 9, contains a larger proportion than the others of iron, and consequently burns a bright red. It is used largely for making roofing tiles, and is mixed with the buff-coloured clay for brick-making. A chemical analysis of No. 9 was made.

It is interesting to note that the gravelly sub-soil covering these clays, containing a large proportion of iron

oxides/

oxides, is frequently added to the extent of from 15% to 20% to the other clays, in order to enhance the red colour of the burnt products. It has, of course, to be sieved and finely ground before mixing.

The clays all contain limonitic concretions distributed throughout the formation, varying greatly in size. Usually some organic matter forms the nucleus, with concentric layers of limonite and hydrohaematite of varying shades of brown and red.

Chemical Properties.

According to Searle (Natural History of Clay), these clays may be classified as secondary, derived by weathering "in situ" of a primary clay or shale.

The essential constituent of all clays is an hydrated alumino-silicate, or mixture of alumino-silicates, for which various names have been proposed. The essential constituent in secondary clays is named Pelinite, which is the analogue of Clayite in primary clays.

Average samples of the clays Nos. 2 and 9 in the claybank in the brickfields were taken and analysed. These two represent the upper and lowermost clays exposed in the bank. The percentage composition of each is as tabulated:-

	No. 2.	No. 9.
SiO_2	74.10%	72.80%
Fe_2O_3	2.11	5.58
Al_2O_3	15.14	10.64
MgO	trace	5.28
CaO	-	trace
H_2O (combined)	4.69	3.74
MnO_2	-	trace
	96.04	98.04

Analyses do not include alkalies

Before/

Before analysis, the clay was dried at $110^{\circ}C$, to drive off the hygroscopic water, and then weighed.

The alkalies in each case were not determined. No. 2 contains a certain amount of organic matter, as the clay darkened in spots on being heated, these spots disappearing only after prolonged heating at a high temperature.

It is at once evident that No. 2 has been weathered to a greater extent than No. 9, and is consequently more leached. No. 9 contains a high percentage of magnesia, while No. 2 contains only a trace. A notable absentee is lime; No. 2 contains none and No. 9 a trace. This means that a certain amount of chalk can be added to counteract the colouring due to iron in the burnt ware. The silica content is high, but this is due to the fact that there is a large amount of free silica present as sandy material, and this was not removed before analysis.

The results for the alumina-water ratio, are unsatisfactory as far as the composition of the pelinite molecule is concerned, being 3.2:1 in No. 2 and 2.8:1 in No. 9. A mean of these two, however, gives the ratio 3 : 1 which works out very nearly to $Al_2O_3.2H_2O$.

Pelinite differs from Kaolinite, the true clay substance, in certain respects, being colloidal etc., but has the same average composition, which is usually represented as $Al_2O_3.2SiO_2.2H_2O$. The actual amount of "clay substance" in clay No. 2, computed from the above formula, works out to be 38.09%. The amount of silica present as adventitious material, either free quartz or silicate impurities, is then 56%. This high percentage of silica is bound to render the clay refractory. The true clay substance in No. 9 amounts to 26.9%, but the large percentages of iron and

magnesia/

magnesia will probably render this clay less refractory than No. 2.

Physical Properties.

The physical are by far the most important properties of a clay, and may differ to a very great extent even in closely related clays. This has been found to be the case in the brickfield clays.

The most striking difference is at once noticed by the variety of colours presented in the clay bank; a second difference can readily be observed by "feeling" the clay for grit. The amount of sandy material in clay No. 2 was determined by means of sieving, the proportions and dimensions of the grains being as follows:-

Size Range	Percentage.
Above 1 mm diameter	nil
1 mm to 0.5 mm	0.17%
0.5 mm to 0.25 mm	4.36%
0.25 mm to 0.125 mm	15.7%
0.125 mm to 0.062 mm	27.83%
Less than 0.062 mm diameter	51.39%.

These figures indicate that about 40% at least of the clay consisted of sand and grit. Twenhofel regards the particles with diameters ranging between 0.0625 mm and 4μ as silt, true clay particles being less than 4μ in diameter. Hall and Oden place the limiting dimension at 2μ. Finer sieves than 0.0625 mm mesh were unobtainable, so that further information as to the grain size of the clay could not be obtained.

Reliable data as regards the proportion of sand in No. 9 clay could not be obtained, as the clay needs grinding to bring it to powder form, and this would tend to break up the grains to a certain extent.

Shrinkage.

The amount of shrinkage that a clay undergoes when

drying/

drying, and during firing, has to be carefully determined before being put to any practical uses.

The shrinkages of nine different clays and mixtures of clays when pressed, dried, and burned under the same conditions, were determined under the direction of Mr. Scarrott, the Manager of the Grahamstown Brickfields.

It is assumed in the table given below, that the shrinkage is uniform so that a linear measurement will suffice for computation. The temperature to which the bricks were raised during burning is approximately 1,000° C.

Size of bricks when pressed - 9½ inches.

Clay	Dry.	Shrinkage	Burnt	Shrinkage.
No. 1.	9⅜ inches	1.31%	8⅝ inches	8%
2.	9	0.66%	9	4.63%
3.	9	1.97%	8½	8.72%
4.	9¼	2.63%	8⅞	4.05%
5.	9¼	2.63%	8	4.73%
6.	9⅛	3.95%	8⅞	2.74%
7.	9	5.26%	8	3.47%
8.	9	1.97%	8⅝	7.38%
9.	9⅜	1.31%	9	3.33%

These figures indicate that clays Nos. 2 and 9 are the best for practical purposes, since they have the least total shrinkage. This means that articles manufactured from them are not so liable to crack during drying and to warp during firing.

No. 4 clay is from the black carbonaceous band mentioned as interbedded with No. 3. No. 5 is the bed of purple clay, and Nos. 6, 7 and 8 are mixtures. No. 1 is an unbedded superficial deposit, which when burnt is a dark red in colour. It is mixed with No. 9 for the manufacture of

roofing/

roofing tiles.

Plasticity.

The plasticity of the clays seems to vary with the amount of weathering undergone. Thus No. 2 is most plastic and No. 9 the least plastic of the clays in the bank. For practical purposes, however, the clays all possess this property to the required degree, and do not need to be treated before use. None of the clays is so plastic as to require the addition of sand to render the work of the pugmills and presses easier.

Refractoriness.

No determinations of the refractoriness of the clays have been made owing to the lack of suitable furnaces and pyrometers. Professor Armstrong, late of the School of Art Grahamstown, has succeeded in vitrifying a very fine white clay obtained from Mr. C. Palmer's farm, and which is probably much the same as No. 2 in the Brickfields. Before firing, however, Professor Armstrong removed as much of the silica as possible by sieving, and also got rid of most of the iron by means of a powerful electromagnet. The firing was done in a specially constructed coke-oven, and vitrification was only achieved after much experimenting.

Mr. Scarrott estimates the temperature at which the bricks are burnt to be from 900° to 1,000°C, while the drain-pipes made from No. 2 clay are burnt at about 1,100°C. There is no sign of vitrification in the clay at this temperature.

Microscopic Examination.

Under the microscope the clay is seen to consist of crystalline and amorphous substances. The crystalline substances are found to be quartz, felspar and mica. Quartz grains are by far the most abundant, and constitute the

larger/

larger grains.

These grains are rounded and subangular, and are usually cracked. The surface of the grains seems to be rough and uneven.

Felspar grains are only with great difficulty distinguishable owing to alteration and disintegration of the particles. These are cloudy and milky in appearance.

The Mica flakes are probably of secondary origin and are rare. The dimensions of the flakes are extremely small, and are only recognisable by their strong birefringence.

The iron in the clay is present probably as magnetite, the grains being well rounded and ranging in size from 0.5 mm to 0.125 mm diameter.

The amorphous material is probably only amorphous in appearance owing to its extremely fine state of division. Under the one-twelfth inch oil immersion lens nothing definite could be distinguished in the mass. Brownian Movement in the particles was observed.

Clay Derived from Dwyka Tillite.

A large amount of clay has been formed in places by the weathering of the Dwyka Tillite, occurring as white patches on the slopes of the escarpment north of the City. Good examples may be found near Makana's Kop, near Sugarloaf Hill, and on the Grahamstown Golf Course.

These patches exposed to sun and rain have naturally been subjected to extreme conditions of weathering and leaching, and have become white in the process. Ordinarily the tillite weathers to a buff, sandy clay. A characteristic feature of the weathering of the tillite is the pointed slabs of rock sticking perpendicularly through the soil.

This/

This may be observed near the Location and Belmont Valley.

The clays are usually easily distinguishable from that derived from the shales, owing to the large proportion of gritty material in the former. The patchy appearance of the clay is due to the weathering of the inclusions, and very often some of the boulders, notably the quartzites, have resisted the effects of weathering and occur in profusion.

None of the particles in the clay from the shales are over 1 mm in diameter, whereas the tillite clay contains quite a large percentage of coarse material over 1 mm diameter.

Economic Aspects.

Grahamstown bricks and tiles have made quite a name for themselves in South Africa and have been manufactured locally practically ever since the founding of the City. The industry is gradually growing, but exceedingly slowly. This is chiefly due to the fact that coal, used in the kilns, is an expensive item, and makes competition with other brickfields, situated nearer the coal pitheads, very difficult.

No article of poor quality is produced, chiefly so on account of the very good quality of clay which is utilised.

Mr. Scarratt has been conducting experiments and research on the merits of the clays, with a view to producing a better finished article at a lower cost.

By mixing the various clays in definite proportions, he has succeeded in setting two standards, producing two very uniform types of bricks, known as first and second class. Class 1 bricks are very hard and of a deep red colour.

Class/

Class 2 have been produced by adding a small proportion of coal dust and sawdust to the clay, and burnt with plenty of draught. The brick produced is lighter in colour than the class 1 brick, is more porous, but has been produced at a much lower cost, owing to the fact that the task of the kilns is greatly reduced, and the coal bill consequently decreased. Class 2 bricks are by no means of a poor quality and are in great demand.

With a view to the production of drain pipes in the near furure, a number of pipes were made from the different clays, and the product of No. 2 clay was found to be superior to any other. It was burned to a high temperature, and salt glazed, the finished product being free from flaws of any description, and of a creamy light brown colour.

Preparations are being made at present for the production of drain-pipes on a small scale, as a very favourable report was received from an English firm to which few sample drain pipes were sent.

The roof and flooring tiles manufactured have been improved considerably by hand-finishing, and by paying more attention to the processes of drying and firing. The object in view is uniformity of the finished articles, and no effort is being spared to attain this end.

At various times in the past attempts have been made at making pottery from the clays, and most of these attempts have met with some measure of success.

Professor Armstrong, late of the Art School, did a large amount of research work, extending over several years, on the white clays found in various localities, but his chief trouble was that he could not obtain a small furnace in which a sufficiently high temperature for vitrification of the pottery could be attained.

Nevertheless, he has succeeded in demonstrating that clay, eminently suited for the manufacture of high class pottery is obtainable locally.

Professor Armstrong stated that he sent a few selected samples of white clay, obtained from Fairholm, to a firm in Cornwall, and a highly satisfactory report was received from them; in fact, Professor Armstrong was informed that his clay was the fifth best in the world.

For good class pottery, however, the clay would require careful treatment and purification. A large porportion of silica could be removed by sieving, and most of the iron would have to be removed, to produce a white article after firing. A small proportion of chalk could be added which would have the effect of decreasing the refractoriness somewhat, and would also reduce the colouring effect of the iron. Much of the iron could be removed by means of an electromagnet.

For practical purposes, the amount of workable clay is practically unlimited.

Most of the clay is outside the Grahamstown Commonage and from the commonage boundary westwards, there must be at least two square miles of clay at the surface, although much of it is covered by surface quartzite. It must be added that this represents only the portion covered by the accompanying map, however, and it is likely that the deposit of clay extends much further westwards.

Assuming that the clay is weathered uniformly to a ~~much~~ depth of 30 feet, there must be approxmiately 62 million cubic yards available, none of which is further than about two miles from the railway. If bricks are made from the

clay/

clay at the rate of a million a month, the supply of clay will last for over 2,000 years. These figures merely serve to show what a large quantity of clay is available for use, and that the clay from the tillite, although adaptable, need never be utilised.

Conclusion.

The occurrence of clays around Grahamstown is probably unique in that it is the largest body of homogeneous, residual white clay in South Africa. A striking feature is the great depth to which the shales have been weathered and leached.

The main reason why a flourishing ceramic industry does not already exist in Grahamstown, is probably the high price of coal delivered locally. The demand for ceramic wares is on the increase, according to figures published by Adams[x], and the quantity of imported articles is decreasing annually, due to the growth of the industry at Vereenining, Olifantsfontein and Cape Town.

High class pottery such as household porcelain and china are still being imported to a large extent, and it is not likely that foreign competition could be eliminated at present. Before undertaking the manufacture of these articles, much research as to the economic value and limits of usefulness of the local clays would have to undertaken.

The process of purification of the clays ought not to present any difficulty, and it is likely that a very good quality china clay could be obtained, and exported as raw material. China clay is very much in demand in the manufacture of paper, paints, putty, etc., where it is used

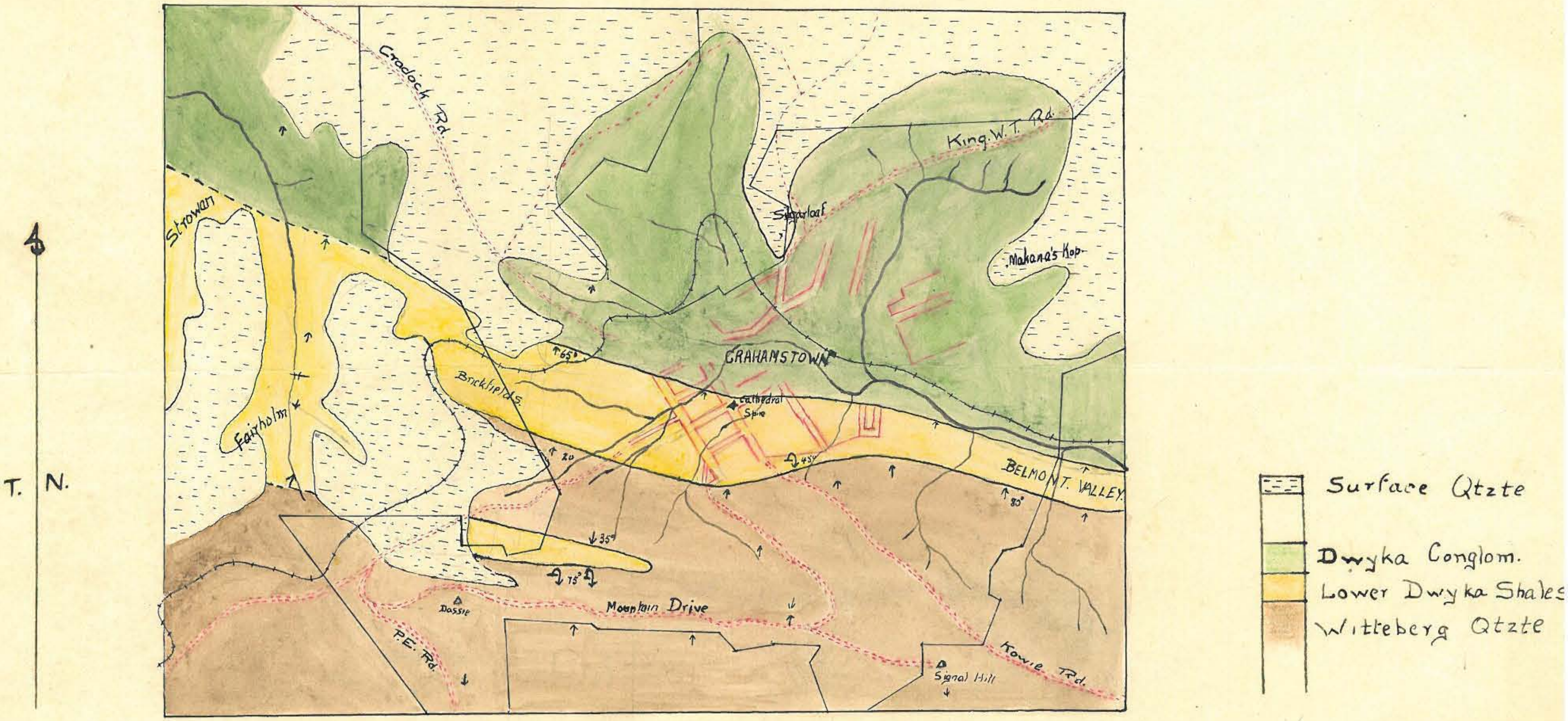
as/

x Adams: Manufacture of Ceramic Wares, S.A. Journal of Industries, May, 1918.

as filler.

Research and practice would naturally reveal any difficulties in the way of establishing an industry locally, but, judging from facts already obtained, and by comparison with other clays, at present, it appears that if some arrangement could be made whereby coal is delivered locally at a cheaper rate, the establishment of the industry by a number of people who are interested, would receive a strong impetus.

Reduced Copy



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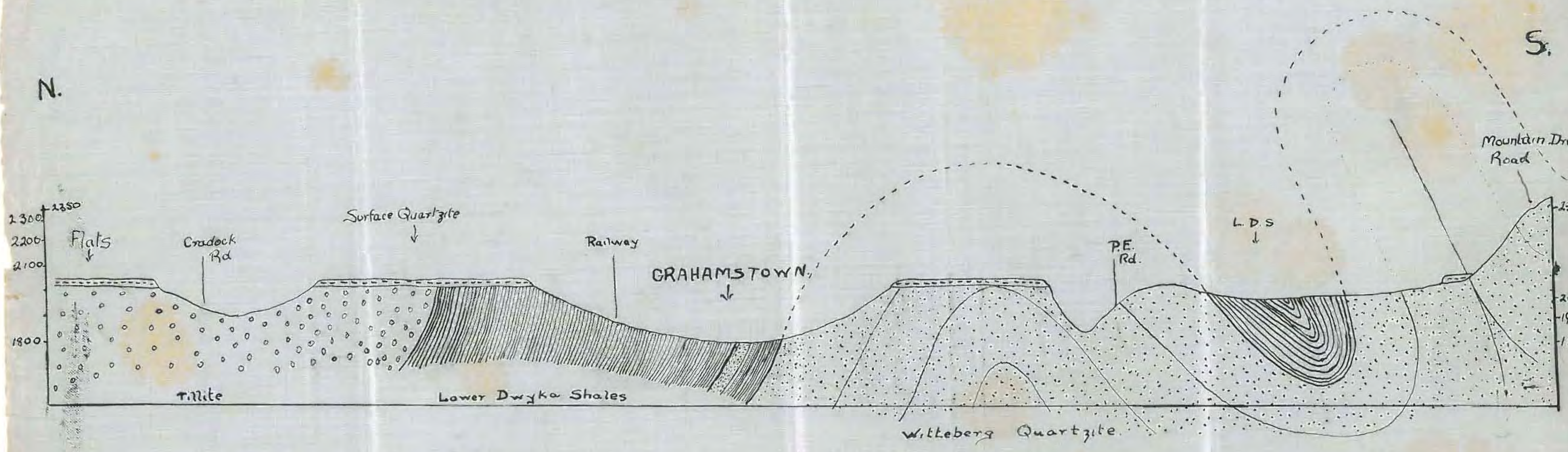
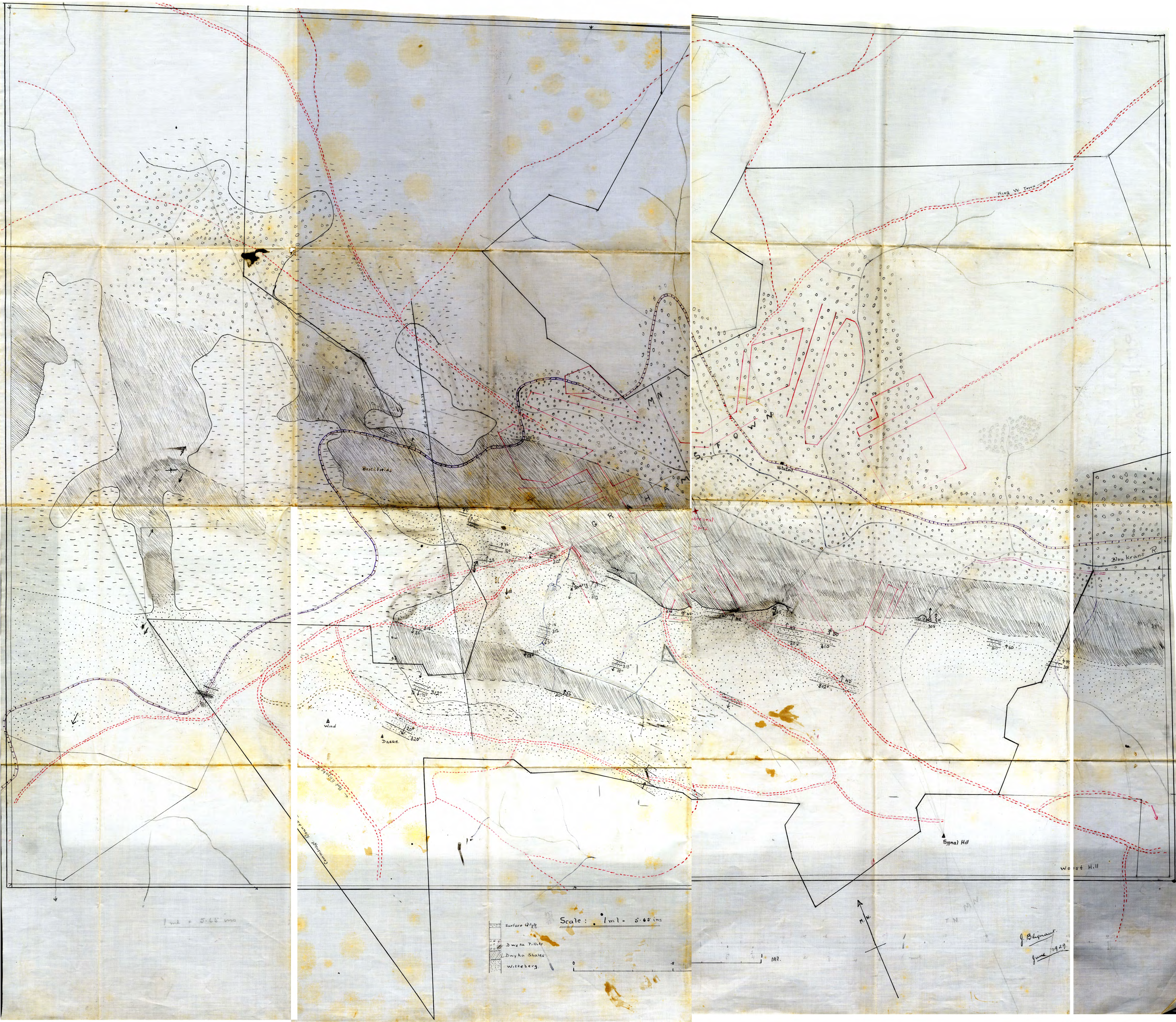


Vertical Scale = 2x Horizontal.



Brickfields
GRAHAMSTOWN
King W. Town
Blou Krans R
Signal Hill
Woest Hill
Wind
Dassie
Scale: 1 ml = 5.65 ins
Surface Qtzte
Dwyka Tillite
L. Dwyka Shales
Witteberg
M.N.
T.N.
J. Blignaut.
June 1929