THE SEDIMENTARY PETROLOGY OF SOME KANSAS AREAS

by

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INTRODUCTION

A study of the sediments of parts of Russell County, Ellis County, Geary County and the Manhattan area was undertaken in an attempt to determine the relative value of geologic field surveys, and sedimentary petrology in establishing relationships between mantle rock and parent material.

It was thought that in order to accomplish this purpose, the following questions should be considered:

1. Is it possible to determine the origin and geologic history of a mantle rock from field observations alone?

2. Is the grain size and the degree of sorting displayed by a parent material reflected in the mantle rock produced by the weathering of that material?

3. Is there a definite mineralogical relationship between mantle rock and parent material?

The data presented are the results of studies conducted on the following materials which were classified on a basis of lithologic characteristics and geologic origin.

1. Glacial drift.

2. Mantle rock residual from shale and chalky limestone.

3. The Tertiary terrace along the Smoky Hill River in Russell County, Kansas.

4. Shale.

5. Limestone.

Field Survey Procedure

Geologic surveys of the areas sampled were made. The purpose of these surveys was to obtain detailed information regarding the stratigraphy and the lithologic characteristics of the rocks located in each area. It was assumed that a comprehensive study of the mantle rock and bedrock relationships must include a detailed knowledge of the bedrock. This was thought to be particularly true in respect to residual mantles.

Variations in the mineral composition and lithologic characteristics existing between such rocks as limestone and shale dictated the necessity of maintaining perfect stratigraphic orientation.

Ground water movement was observed to be largely controlled by the nature and attitude of the bedrock. This control was reflected in the mantle rock and in the type and amount of vegetation. A thorough knowledge of the stratigraphy of the area being studied was of considerable value in predicting the nature and elevation of the various buried bedrock formations.

Care was exercised in taking the samples so that unrepresentative sampling would be kept to a minimum. The method described by Twenhofel (3) was the sampling method employed in this study. Efforts were made to avoid taking samples in places where unusual weathering conditions were thought to exist.

Each sample was numbered, the depth at which it was taken was recorded, and the location was described by the township, range and section method.

Laboratory Procedure

The samples were air dried, each sample was thoroughly mixed and quartered, and half of the sample was then stored, and the remaining half was used for mechanical and mineral analysis.

The portion of the sample which was used for mechanical analysis was thoroughly air dried. A 50 gr. portion was weighed and placed in a 450 cc. shaker bottle, 20 cc. of a .125 per cent solution of sodium silicate was added to act as a dispersing agent. The bottle was placed in a mechanical shaker and the sample was aggitated until it was thoroughly dispersed. The dispersed sample was washed into a mechanical analysis tube, and the mechanical analysis data were then obtained by using the Bouyoucos hydrometer method (1).

After completion of the mechanical analysis procedure, the data were calculated on a percentage basis, and cumulative curves were plotted. The arithmetic and geometric quartile deviations, the arithmetic and geometric quartile skewness, and Trask's sorting coefficient were calculated.

Mineral Analysis Procedure

The amount of sample most suitable for mineral analysis was found to vary somewhat with different types of material. In most cases 50 gm. of glacial material yielded representative heavy mineral suites which were of sufficient size and variety to give a true picture of this fraction of the sediment. Accurate mineral analysis of shales, limestones, and mantle rock residual from shales and limestones, required the use of from 500 to 1,000 gm. of material. This was due to the small amount of heavy minerals contained in such sediments.

The 1/16 mm. size was removed from the sample during the mechanical analysis, and was used for the purpose of mineral analysis. This portion of the sample was washed into a beaker and boiled in a .5 normal solution of hydrochloric acid for approximately 5 minutes. The acid treatment was necessary because it removed coatings and calcite cement from around the grains. This made the mineral identification procedure easier.

The acid treated samples were washed free of acid and examined for organic matter. Samples which contained organic matter were boiled in a 15 per cent solution of hydrogen peroxide until oxidation of the organic matter was complete. The acid and hydrogen peroxide treated samples were rescreened to insure proper sizing for mineral analysis.

Sedimentary petrologists have found that a separation of the mineral constituents of sediments on a basis of specific gravity aids greatly in the study of these materials. Heavy liquids having a specific gravity of approximately 2.87 were used in making the mineral separations. The minerals which floated in these liquids were designated the light fraction and those that settled were designated the heavy fraction.

The light fraction was found to constitute approximately 98 per cent of the sample, and was composed essentially of such minerals as quartz, chalcedony, various feldspars, and the clay minerals. The heavy fraction was found to consist of such minerals as apatite, augite and diopside, basaltic hornblende, biotite, chlorite, corundum, epidote, garnet, hornblende, kyanite, magnetite, muscovite, other opaques, rutile, sillimanite, titanite, topaz, tourmaline, and zircon.

After the mineral separations were completed, the light and heavy fractions were washed in alcohol to remove the traces of the heavy liquid used in the separations, and these fractions were subsequently dried under a heat lamp. Mineral mounts of the light and heavy fractions were made. Canada balsam, having an index of refraction of 1.54, was used as the mounting medium.

During the petrographic analysis of the samples, minerals of both the light and heavy fractions were identified, grains were counted and the percentage of each mineral was calculated. Note was made of such features as the degree of weathering and the presence or absence of unstable, and authigenic minerals.

REVIEW OF LITERATURE

The stability of any mineral is very largely dependent upon its physical and chemical properties, and the nature of the weathering environment to which it is subjected. As a result of the strong influence which certain weathering environments impose on minerals there has been considerable controversy among mineralogists regarding the classification of minerals on a basis of stability. Milner (2) arranges the common detrital and authigenic minerals found in sediments in the following stability groups; 1. Stable, 2. Moderately stable, and 3. Unstable. A few of the common stable minerals according to Milner are: anatase, chalcedony, corundum, epidote, gypsum, kyanite, leucoxene, magnetite, monazite, montmorillonite, muscovite, oligoclase, orthoclase, quartz, rutile, sillimanite, spinel, staurolite, titanite, topaz, tourmaline, zircon, and zoisite. Some of his moderately stable minerals are: aegirine, albite, augite, barite, celestite, clinozosite, enstatite, hematite, hornblende, hypersthene, labrodorite, microcline, and nontronite. He lists the following minerals found in sediments as unstable: anorthite, apatite, bytownite, olivine, periclase, and sulphur.

As previously indicated all workers are not in complete agreement on mineral stability. However, Twenhofel's (3) mineral stability lists are essentially the same as those of Milner. Krumbein and Pettijohn (4) present a list of the common detrital minerals in which the reaction to various solvents is given.

The inadequacy of field observation alone in determining relationships between bedrock and mantle rock was indicated by Rigg (5). He showed that each soil series in the area studied coincided in area with a geological formation, and that the related geological formations gave rise to a series of related soils. This relationship was more pronounced with respect to the mineral constituents than it was to textures.

Buckhannan and Ham (6) found heavy mineral suites to be of considerable value in distinguishing old and recent alluvium transported from the High Plains, and from the "Red beds". The materials washed from the High Plains contained epidote and in some places augite, kyanite, and brown or basaltic hornblende, whereas these minerals were not found in the sediments which were genetrically related to the "red beds". Boswell (7), in his studies of the stratigraphy, and petrology of the lower Eocene deposits of the Northeastern part of the London basin, found corundum, sillimanite, and other minerals to be of correlative value.

Jeffries and White (8), in their studies of soils residual from limestone and dolomite, found that the mineralogical characteristics of the acid insoluble residue of the rock was in general reflected in the soil profile.

Numerous studies of the mineral composition of glacial till have been made. Harned (9) has contributed valuable information concerning the mineral and mechanical analysis of the mantle rock of the Manhattan area. His studies of this area included mineral and mechanical analysis of the glacial material located in the vicinity of Manhattan, Kansas. He found that mineralogical and mechanical analysis of the sediments constituted an excellent basis for determining the origin of the mantle rock in this area. He likewise indicated that field observations and physical appearances alone are insufficient critera for establishing the origin of mantle rock in this area.

The red clay-like deposits in eastern Kansas along the Kansas River from Manhattan, Kansas to Kansas City, Kansas were studied by Hoover (10) who concluded from mechanical analysis and mineralogical studies that the material was highly weathered glacial till.

Several methods of presenting mechanical and mineral analysis data have been devised. Most of these methods are outlined by Krumbein and Pettijohn (4).

GENETIC RELATIONSHIPS OF SOME BEDROCK AND MANTLE ROCK SAMPLES OF RUSSELL COUNTY AND ELLIS COUNTY, KANSAS

Approximately 40 mantle rock and bedrock samples from Russell county and Ellis county, Kansas were studied in an effort to determine the genetic relationships existing between these two general types of material.

The number designation, the depth, location, and the bedrock formations of some of the samples studied are as follows:

Sample 8/45 - 1 series.

NW$\frac{1}{4}$ Sec. 5 T145 R13W

1A - depth - 3 feet.

1B - depth - 5 feet.

1C - depth - 6 to 7 feet.

1D - depth - 8 feet.

1E - depth - 9 to 10 feet.

1F - depth - 12 to 13 feet. Fairport shale.

Sample 8/45 - 3 series.

SW$\frac{1}{4}$ of the NE$\frac{1}{4}$ Sec. 8 T145 R11W.

3A - depth - 2 feet.

3B - depth - 4 to 6 feet.

3C - depth - 9 to 10 feet.

3E - depth - 15 to 16 feet.

Sample 8/45 - 5 series.

SW$\frac{1}{4}$ of the NE$\frac{1}{4}$ Sec. 12 T145S R12W.

5A - depth - 6 to 7.5 feet.

5B - depth - 9 to 10 feet.

5C - depth - 10 to 11.5 feet.

5D - depth - 12.5 to 13 feet.

5E - depth - 15 feet.

5F - depth - 17 feet.

Sample 8/45 - 16A and 16B.

$NE\frac{1}{4}$ of the $NE\frac{1}{4}$ Sec. 10 T13S R14W.

16A - top soil.

16B - bedrock - Fairport shale.

Sample 8/45 - 17A and 17B.

$SE\frac{1}{4}$ of the $SE\frac{1}{4}$ Sec. 3 T13S R14W

17A - depth - 0 to 1.0 feet.

17B - bedrock - Pfeifer shale.

Sample 8/45 - 18A and 18B.

$SE\frac{1}{4}$ of the $NE\frac{1}{4}$ Sec. 34 T12S R14W.

18A - depth - 0 to 1.0 feet.

18B - bedrock - Jetmore chalk.

Sample 8/45 - 13.

Location 2.5 miles south of Fort Hays, Kansas. Sample taken at the Kansas State Agricultural Experiment Station along Highway K183.

13 - depth - 4 to 8 feet.

Sample 8/45 - 14A.

Location approximately 10 miles south of Fort Hays, Kansas along Highway K183.

14A - depth - 1 to 3 feet.

Sample 8/45 - 20B.

Sec. 31 T14S R11W.

20B - bedrock - Graneros shale.

Russell and Ellis Counties, Sample Series Number 1

The samples of series number 1 were taken from a terrace which parallels the Smoky Hill River through Russell and Ellis counties. Samples were taken at various depths by means of a soils auger.

The soil maps of Russell and Ellis counties, show the mantle rock from which samples of series number 1 were taken to be residual from the underlying Fairport shale; however, the petrologic evidence necessary for the classification of these materials as residual from the underlying bedrock was not found (Table 1). The average heavy mineral fraction of the mantle rock samples contained 11.8 per cent of the mineral biotite, whole no biotite was found in the bedrock samples. Several other minerals, such as corundum, leucoxene, magnetite, monazite, rutile, sericite, and sillimanite were found to be present in varying percentages in the mantle, but none of these minerals were represented in the underlying Fairport shale. The heavy mineral fraction of the Fairport shale contained 5.4 per cent garnet, 5.8 per cent titanite and 9.9 per cent zircon, while the overlying mantle contained 3.8 per cent garnet, 2.5 per cent titanite, and only 1.2 per cent zircon. It was thought that if the mantle rock from which the samples of series number 1 were taken had originated from the weathering of the underlying Fairport shale, the mantle rock would show an accumulation of such stable minerals as garnet, titanite and zircon.

The light mineral fractions of series 1, and the Fairport shale varied somewhat; however, the limited size of the mineral suites involved led to the belief that these data were not significant.

Mechanical analysis of a sample from series number 1 and of the Fairport shale gave very different results, as shown in Table 1A. The sorting coefficient of sample 1B was 2.03, while that of the Fairport shale was 8.02. Trask, and others (4) have found that a sorting coefficient of less than 2.5 indicates a well sorted sediment, a value of about 3.0, a normally sorted sediment and a value of greater than 4.5, a poorly sorted sediment. It was thought that a sorting coefficient of 3.0 or more indicated that the material could not have been transported by aeolian, fluvial, lacustrine or glacial agents. Accurate mechanical analysis of bedrock formations was considered to be very difficult. This is due to the possibility of incomplete dispersion, the presence of micro-fossils, and the probability of the presence of minerals of epigenetic origin.

Russell and Ellis Counties, Sample Series Number 3

The samples of series 3 were taken at the previously indicated locations from the terrace which extends along the Smoky Hill River in Russell and Ellis counties.

The mantle rock from which these samples were taken has previously been mapped as residual from the underlying Graneros shale, but mineralogical and mechanical studies indicated a complete lack of genetic relationships between the mantle rock and the underlying bedrock formation. The mineral and mechanical analysis data for these materials are shown in Table 1.

The average heavy mineral fraction of the samples of series 3 showed significant percentages of several minerals which were absent from the underlying Graneros shale. Some of these minerals were apatite 0.5 per cent, augite and diopside 2.7 per cent, basaltic hornblende 3.6 per cent, biotite 8.0 per cent, magnetite 9.5 per cent, and zircon 2.9 per cent.

In most cases the minerals found to be present in the bedrock were represented in the overlying mantle, but in several instances the mantle rock failed to show the accumulation of stable minerals which was thought necessary to warrant their being classified as residual. The heavy mineral fraction of the Graneros shale contained 3.0 per cent tourmaline, and 1.4 per cent rutile, while the average heavy mineral fraction of the samples of series 3 contained only 0.7 per cent tourmaline and 0.6 per cent rutile.

The mechanical analysis data indicated that the mantle rock was better sorted than the bedrock. Sample 3C was found to have a sorting coefficient of 1.37, while the sorting coefficient of the Graneros shale was 3.16.

Russell and Ellis Counties, Sample Series Number 5

In general, the statements made regarding series 1 and series 3 apply equally well to the samples of series 5. These samples were also taken from the terrace along the Smoky Hill River, and have previously been considered to be residual from the Graneros shale; however, as in series 1 and 3, no petrologic evidence was found to substantiate such a classification.

Some of the minerals which were present in the mantle rock but absent from the bedrock were augite and diopside 0.4 per cent, basaltic hornblende 3.1 per cent, magnetite 19.3 per cent, monazite 1.4 per cent, and topaz 0.9 per cent. The heavy mineral fraction of the Graneros shale contained 3.0 per cent tourmaline, while the average heavy mineral fraction of the samples of the overlying mantle rock contained 1.2 per cent of this mineral.

Differences in the light mineral fractions of the mantle rock and bedrock were found to exist. The light mineral fraction of series 5 consisted of 11.4 per cent chalcedony, 7.3 per cent orthoclase, 1.9 per cent plagioclase, and 79.1 per cent quartz, while that fraction of the Graneros shale consisted of 2.0 per cent chalcedony, 1.0 per cent orthoclase, a trace of plagioclase, and 97.0 per cent quartz. This difference is probably not significant.

Observations of mechanical analysis data indicated sample 5C to have a sorting coefficient of 1.92 and the Graneros shale to have a sorting coefficient of 3.16. The sorting coefficient of 1.92 for the mantle rock sample was considered to be indicative of a transported origin and it was thought that the transporting agent was probably fluvial.

Table 1. Mineral analysis of some transported mantles and underlying bedrocks from Russell and Ellis County, Kansas.

Minerals	Series 1 8/45/1A, B,C,D,E	8/45/1F Fairport Sh.	Series 3 8/45/3A, B,C,D,E	Series 5 8/45/5A, B,C,D,E,F	8/45 13	8/45 14A	8/45/20B Graneros Sh.
				Heavy fraction			
Apatite	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Augite & Diopside	Tr	0.0	2.7	0.4	0.0	0.0	0.0
Barite	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Basaltic Hbld.	2.9	0.9	3.6	3.1	2.0	0.0	0.0
Biotite	11.8	0.0	8.0	6.6	1.5	0.0	0.0
Chlorite	Tr	0.0	0.0	0.0	0.0	0.0	0.0
Corundum	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Epidote	18.2	12.6	15.7	13.1	14.1	8.7	3.0
Garnet	3.8	5.4	3.1	3.8	6.6	5.2	0.7
Hornblende	23.7	9.1	45.8	23.1	33.4	16.0	2.4
Kyanite	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leucoxene	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	3.8	0.0	9.5	19.3	18.9	56.0	0.0
Monazite	Tr	0.0	Tr	1.4	Tr	2.5	0.0
Muscovite	12.1	0.9	3.6	6.4	10.9	3.2	67.3
Other Opaques	10.8	54.0	0.0	13.8	0.0	0.0	21.6
Rutile	0.2	0.0	0.6	0.0	0.0	0.0	1.4
Sericite	6.1	0.0	0.0	0.0	2.3	0.0	0.0
Sillimanite	0.3	0.0	Tr	0.0	0.5	0.0	0.0
Titanite	2.5	5.8	2.6	0.4	4.7	2.8	0.7
Topaz	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Tourmaline	1.5	1.3	0.7	1.2	1.0	0.4	3.0
Zircon	1.2	9.9	2.9	5.5	3.7	5.2	0.0
				Light fraction			
Chalcedony	31.0	9.1	11.9	11.4	67.3	20.0	2.0
Gypsum	0.0	9.3	0.0	0.0	0.0	0.0	0.0
Orthoclase	9.9	10.0	2.4	7.3	4.6	11.8	1.0
Plagioclase	2.3	2.2	1.8	1.9	Tr	1.0	Tr
Quartz	56.6	69.6	83.7	79.1	28.3	67.0	97.0

Table 1A. Mechanical analysis data and formulas for derivation.

Formulas

QDa = Arithmetic quartile deviation $\frac{Q3 - Q1}{2}$

SKa = Arithmetic skewness $\frac{Q1 + Q3 - 2M}{2}$

Skg^2 = Geometric skewness squared $\frac{Q1 \cdot Q3}{M^2}$

Skg = Geometric skewness SKg^2

SO = Trask's sorting coefficient $\sqrt{\frac{Q3}{Q1}}$

M = Median size

Q1 and Q3 = 1st and 3rd quartile respectively

Mechanical analysis

Sample No.	QDa	SKa	Skg^2	SO	Q3	Q1	M
Fairport shale	0.241	0.169	0.582	8.02	0.490	0.008	0.086
8/45/1B	0.237	0.002	0.410	2.03	0.063	0.015	0.040
Graneros shale	0.005	0.004	2.300	3.16	0.012	0.001	0.002
8/45/3C	0.027	0.014	1.280	1.37	0.115	0.061	0.074
3/45/5C	0.029	0.009	0.490	1.92	0.082	0.023	0.062

Russell and Ellis Counties, Samples 13 and 14A

Samples 13 and 14A were found to possess the same general mineral constituents as series 1, 3 and 5. The mineral analysis data of samples 13 and 14A indicated an origin similar to that of series 1, 3 and 5, but shows no genetic relationship to the underlying Graneros shale.

Sample 13 contained small percentages of basaltic hornblende, biotite, sericite, and sillimanite but none of these minerals were identified in the Graneros shale bedrock. Both samples 13 and 14A contained the following minerals which were not represented in the bedrock: magnetite, monazile and zircon.

Russell County, Samples 16A and 16B

Sample 16A was taken from a thin upland mantle rock overlying the Fairport shale from which sample 16B was taken.

Petrologic studies of samples 16A and 16B indicated that the mantle rock from which sample 16A was taken had originated from the weathering of the underlying Fairport shale. Table 2 shows the mineral and mechanical analysis data for these samples. In no case were minerals found to be present in one sample and absent from the other. In most instances, even though the percentage of heavy minerals in both samples was low, stable minerals were found to have accumulated in the mantle rock while the bedrock contained higher percentages of unstable minerals than did the mantle rock. Plates I and II are photomicrographs of the heavy mineral fractions of samples 16A and 16B; they show the accumulation of stable heavy minerals in the mantle rock.

The heavy mineral fraction of the mantle rock contained the following stable minerals which were thought to be of correlative value: 5.8 per cent biotite, 1.1 per cent chlorite, 5.8 per cent garnet, 11.5 per cent muscovite, 1.7 per cent titanite, and 3.9 per cent zircon. The heavy fraction of the bedrock contained 4.1 per cent biotite, 0.5 per cent chlorite, 5.4 per cent garnet, 5.9 per cent muscovite, 1.4 per cent titanite, and 0.9 per cent zircon.

The mineral analysis of the light mineral fractions of samples 16A and 16B produced data which were strikingly similar. These minerals, being for the most part moderately stable, were present in both samples in almost equal percentages.

Identical micro-faunas were found to be present in samples 16A and 16B. Plates III and IV are photomicrographs of samples 16A and 16B; they show the micro-fossils to be present in both materials. The slightly reduced abundance of micro-fossils in the mantle sample was attributed to the rapidity with which the soluble tests of calcareous fossils are known to weather.

Russell County, Samples 17A and 17B

Sample 17A represents the mantle rock which overlies the Pfeifer shale, which is the material from which sample 17B was taken. The topography of the area where the samples were taken was gently rolling upland.

Mineralogical and mechanical analysis of these samples indicated that the mantle rock of which 17A was a sample originated from the weathering of the underlying Pfeifer shale.

The heavy mineral fraction of the mantle rock contained accumulations of such stable minerals as garnet, muscovite, titanite and tourmaline. The heavy mineral fraction of the mantle rock contained 0.9 per cent augite and diopside, while these minerals were not identified in the underlying bedrock. This minor discrepancy might be due to the small heavy mineral percentage contained in the bedrock sample.

The light mineral fraction of sample 17A contained a higher percentage of chalcedony and a lower percentage of quartz than did sample 17B. This was not thought to be significant because weathering is known to change quartz to chalcedony while ground water may in addition to changing quartz to chalcedony reverse the process and change chalcedony into quartz.

EXPLANATION OF PLATE I

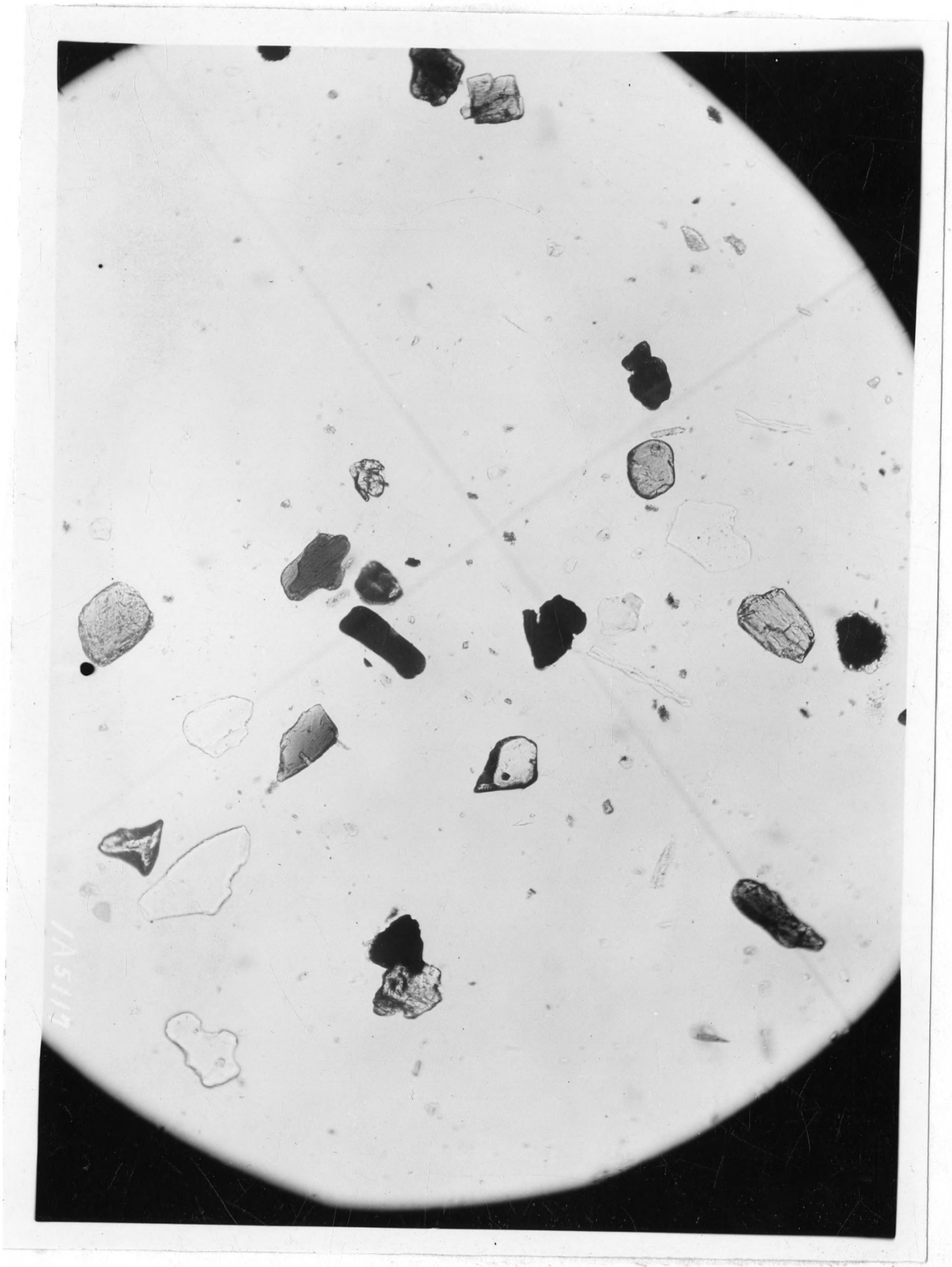
Sample 16B - Fairport shale, heavy mineral fraction.

PLATE I

EXPLANATION OF PLATE II

Sample 16A - Heavy mineral fraction, mantle rock residual from the Fairport shale.

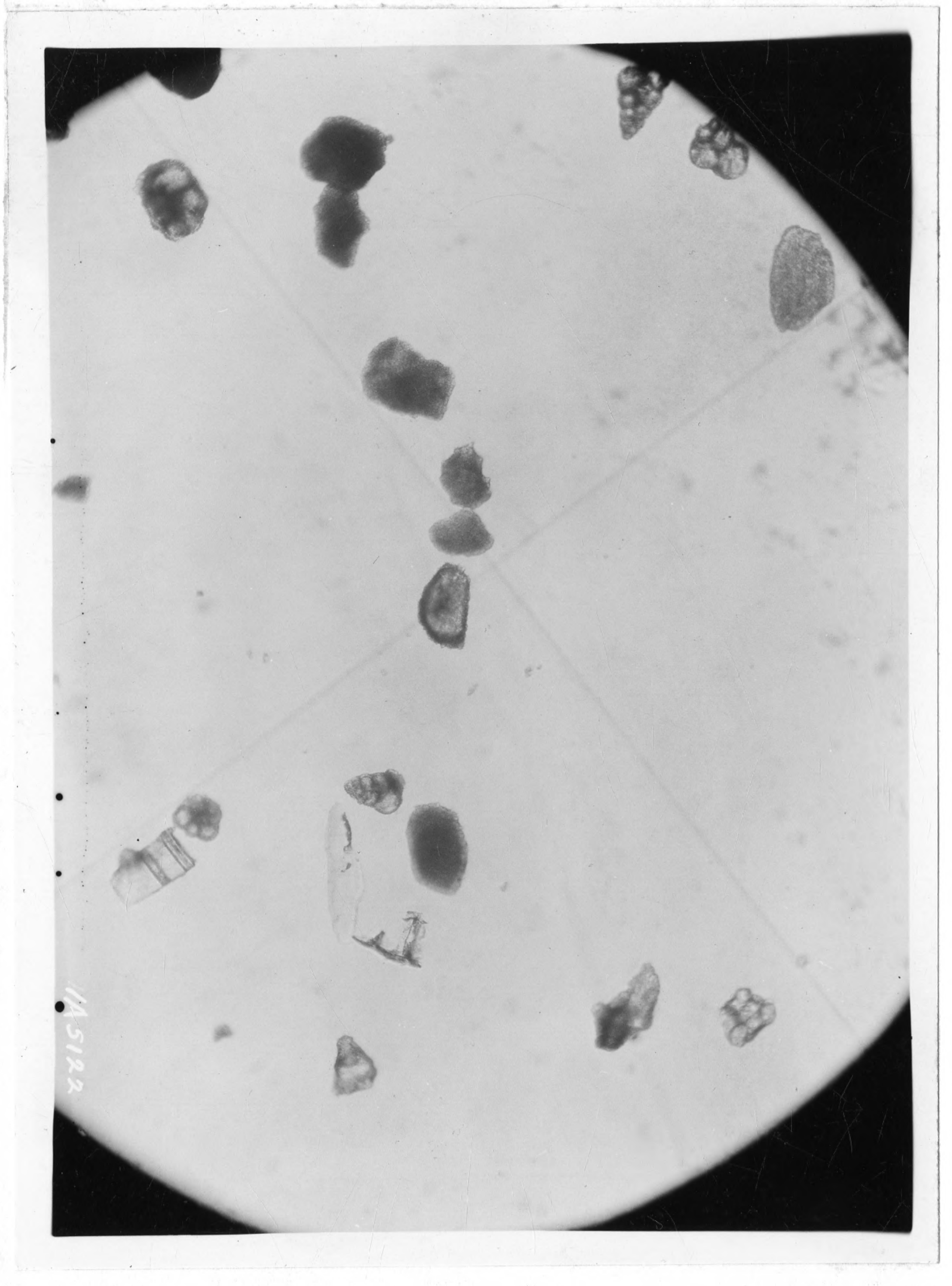
PLATE II



EXPLANATION OF PLATE III

Sample 16A - Light mineral fraction, micro-fossils in mantle rock residual from the Fairport shale.

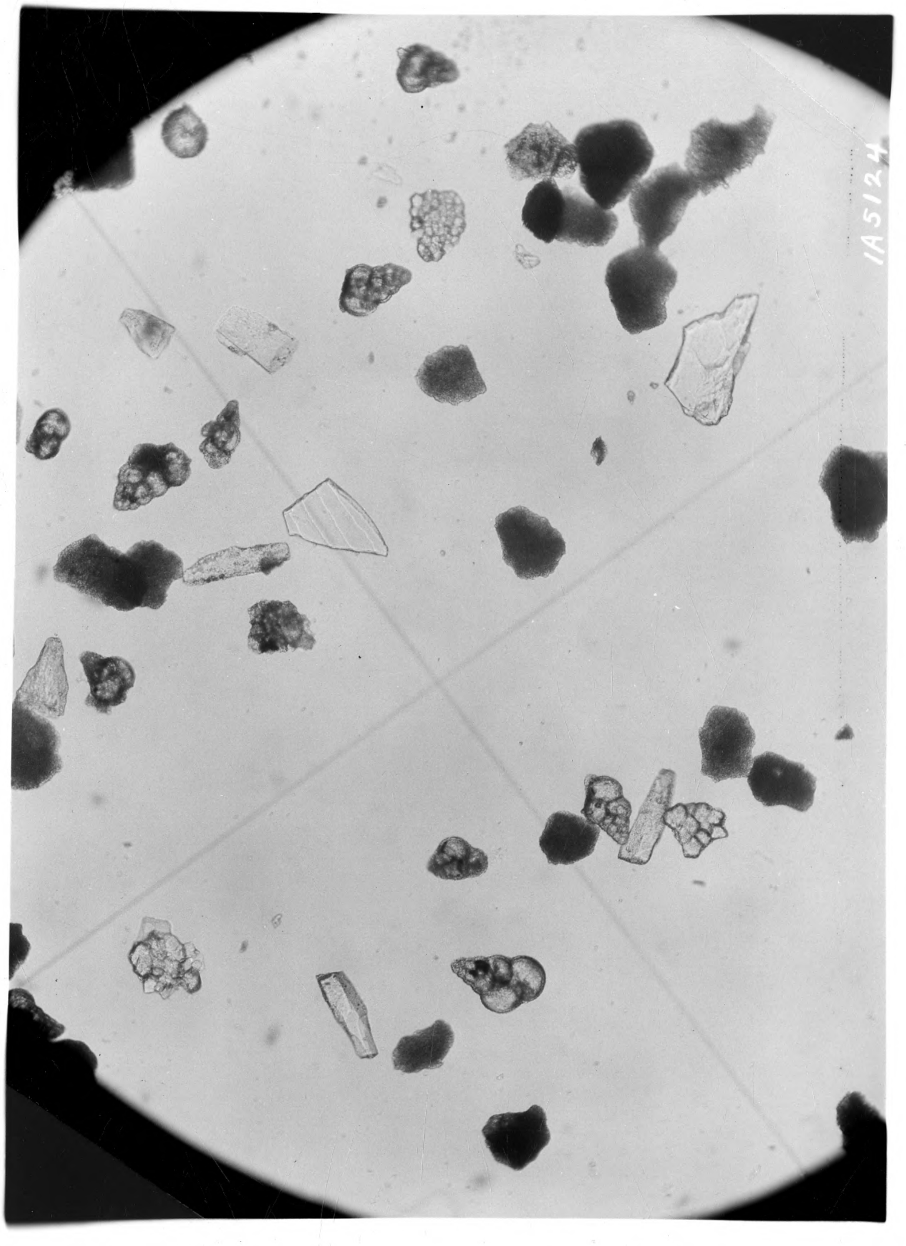
PLATE III



EXPLANATION OF PLATE IV

Sample 16B - Light mineral fraction, micro-fossils in the Fairport shale.

PLATE IV



Russell County, Samples 18A and 18B

Sample 18A was taken from the mantle rock which overlies the Jetmore chalk while sample 18B represents the Jetmore chalk bedrock.

The mineral and mechanical studies of samples 18A and 18B supplied evidence to indicate a residual origin for the mantle rock from which sample 18A was taken. The following stable minerals were present in the heavy mineral fraction of the mantle rock in higher percentages than in the bedrock: corundum, garnet, titanite, and tourmaline. A few moderately stable and unstable minerals, such as basaltic hornblende, epidote and hornblende were found to have accumulated in the mantle rock. This was attributed to the extreme immaturity of the mantle rock.

The mineral analysis of the light fraction of the Jetmore chalk revealed the presence of 1.9 per cent gypsum, while the light fraction of sample 18A contained 14.7 per cent of this mineral. The gypsum in the Jetmore chalk was assumed to be of authigenetic origin and to be relatively stable in the weathering environment to which it had been subjected. The light mineral fraction of the Jetmore chalk contained 49.7 per cent chalcedony, while the light fraction of the overlying mantle contained only 4.7 per cent chalcedony. The high percentage of chalcedony in the bedrock sample was assumed to be local and perhaps due to the action of ground water. The presence of more gypsum and less chalcedony in the mantle rock than in the

Table 2. Mineral analysis of some residual mantles and parent materials from Russell County, Kansas.

Minerals	8/45/16A	8/45/16B Fairport Sh	8/45/17A	8/45/17B Pfeifer Sh	8/45/18A	8/45/18B Jetmore Sh.
			Heavy fraction			
Augite & Diopside	2.7	1.4	0.9			
Basaltic Hbld.			6.8	5.0	2.7	0.9
Biotite	5.8	4.1			0.9	5.3
Barite						
Chlorite	1.1	0.5				
Corundum	0.5	0.9	0.5	0.9	2.3	1.3
Epidote,C&Z	11.9	17.1	8.3	14.9	15.2	9.6
Garnet	5.8	5.4	5.8	3.8	5.5	3.5
Hornblende	28.8	36.9	36.0	33.6	26.2	17.7
Magnetite						
Muscovite	11.5	5.9	16.1	2.9	31.8	45.5
Other Opaques	25.2	23.5	13.3	31.6	10.6	14.8
Rutile						
Sillimanite					Tr	
Titanite	1.7	1.4	3.9	Tr	1.4	1.3
Tourmaline	1.1	1.8	4.0	Tr	0.9	Tr
Zircon	3.9	0.9	4.0	6.9	2.3	0.5
			Light fraction			
Chalcedony	7.0	6.9	16.6	3.6	4.7	49.7
Gypsum					14.7	1.9
Heavy Mineral	Low	Low	Low	Low	Low	Low
Orthoclase	18.9	18.9	13.5	1.4	8.0	4.0
Plagioclase	2.0	5.0	4.0	2.0	1.0	1.0
Quartz	71.5	68.7	65.9	92.9	71.0	42.9

Mechanical Analysis

	8/45/16A	8/45/16B	8/45/17A	8/45/17B	8/45/18A	8/45/18A
QDa	0.029	0.241	0.330	0.428	0.208	0.049
SKa	0.016	0.169	0.274	0.356	0.142	0.028
SKg^2	0.308	0.582	2.790	0.640	0.377	0.599
SKg	0.555	0.763	1.670	0.800	0.614	0.773
SO	2.186	8.024	4.790	13.670	9.760	18.540
M	0.061	0.080	0.086	0.076	0.070	0.002
Q1	0.016	0.008	0.030	0.004	0.004	0.003
Q3	0.074	0.490	0.690	0.860	0.420	0.100

bed rock may reflect the same sort of ground water action.

GENETIC RELATIONSHIPS OF SOME MANTLE ROCK AND BEDROCK SAMPLES FROM GEARY COUNTY

Approximately 30 samples from Geary county, Kansas were studied mineralogically and mechanically in an attempt to establish the presence or absence of genetic relationships between the mantle and underlying bedrock. The average mineral and mechanical analysis data compiled from a large number of samples of known glacial origin from the Manhattan, Kansas area was presented for the purpose of comparison with the Geary county samples.

The following are the designations, locations and descriptions of some of the Geary county samples which were studied:

Geary county number 1 series.

Eastern part of the SE$\frac{1}{4}$ Sec. 29 T12S R8E.

1A - depth - 0 to 0.8 feet. Black top soil.

1B - depth - 1 to 1.6 feet. "B" horizon of the soil.

1C - Weathered Oketo shale.

1D - Unweathered Oketo shale.

Geary county number 2 series.

Southwest part of NW$\frac{1}{4}$ Sec. 34 T13S R8E.

2A - depth - 0 to 0.8 feet. "A" horizon of the soil.

2B - depth - 0.8 to 1.3 feet. "B" horizon of the soil.

2C - depth - 1.3 to 2.0 feet.

Geary county number 3 series.

NW$\frac{1}{4}$ Sec. 33 T13S R8E.

3A - depth - 0.0 to 1.0 feet. "A" horizon of the soil.

3B - depth - 1.0 to 1.5 feet. "B" horizon of the soil.

3C - depth - 1.5 to 3.0 feet.

Geary county number 4 series.

Western part of Sec. 16 T13S R8E.

4A - depth - 0.0 to 1.0 feet. "A" horizon of the soil.

4B - depth - 0.0 to 1.5 feet. "B" horizon of the soil.

4C - depth - 1.5 to 6.0 feet.

Florence limestone sample.

NW$\frac{1}{4}$ Sec. 34 T13S R8E.

Fort Riley limestone sample.

Sec. 16 T13S R8E.

Mineral analysis data of the bedrock samples and of at least one sample from each of the series which are listed are given in Table 3. The mechanical analysis data for a mantle rock sample of series 1 and for the underlying Oketo shale are also given in Table 3.

Geary County, Sample Series Number 1

Samples 1A and 1B of the Geary county number 1 series have been mapped as residual from the underlying Oketo shale which is here represented by samples 1C and 1D. Mineralogical and mechanical studies of these materials failed to produce any evidence to indicate that the mantle rock originated as the result of the weathering of the underlying Oketo shale.

The mineral analysis of the heavy mineral fractions of samples 1C, weathered Oketo shale, and 1D, unweathered Oketo shale, resulted in data which were almost identical. Sample 1D contained 0.5 per cent chlorite, while this mineral was not identified in the heavy mineral fraction of sample 1C. The heavy mineral fraction of sample 1C contained 0.8 per cent rutile, and 0.8 per cent zircon, neither of these minerals were represented in sample 1D. These slight discrepancies, as well as other minor variations in mineral percentages, were assumed to be the result of normal irregularities in mineral composition. The small amount of heavy mineral material per unit volume of samples 1C and 1D was considered to be conducive to slight mineral analysis inaccuracies.

The mineral analysis of samples 1A and 1B of Geary county series 1 supplied data which were considered to eliminate any possibility of the mantle rock they represent being residual from the underlying Oketo shale. The average mineral analysis of the heavy fractions of samples 1A and 1B showed the following minerals to be present in the mantle rock but absent from the underlying bedrock: augite and diopside, a trace, sillimanite 0.6 per cent, titanite 3.0 per cent, and tourmaline 3.6 per cent. The heavy mineral fractions of the Oketo shale samples contained corundum and rutile, while neither of these minerals were identified in the samples of the overlying mantle rock, in spite of their durability.

The light mineral fractions of both of the Oketo shale samples consisted of 100 per cent chalcedony with a trace of plagioclase and quartz, but the light fractions of the mantle rock samples consisted of only 70.5 per cent chalcedony, with 4.0 per cent orthoclase, 14.5 per cent plagioclase, and 11.3 per cent quartz.

The mechanical analysis of sample 1B of the Geary county series 1 showed the sorting coefficient of this sample to be 2.15, while the sorting coefficients of samples 1C and 1D were 4.97 and 4.19 respectively. The mantle rock sorting coefficient of 2.15 was found to be very similar to that of the average sorting coefficient of the glacial sediments of the Manhattan, Kansas area.

Geary County, Sample 2C, Series 2

Recent soils maps indicate the mantle rock from which sample 2C, series 2 was taken to be residual from the Florence limestone; however, careful mineral studies of these materials indicated the mantle rock in question to be of glacial origin.

The heavy mineral fraction of the Florence limestone was found to consist of a somewhat limited mineral suite, while the heavy mineral fraction of sample 2C contained a large variety of minerals. Some of the minerals which were present in the mantle sample but were unrepresented in the bedrock were: augite and diopside, basaltic hornblende, epidote, kyanite, magnetite, muscovite, sericite, sillimanite and titanite. Several minerals were found to be present in the heavy mineral fraction of the Florence limestone in higher percentages than in the overlying mantle rock. The heavy mineral fraction of the Florence limestone contained 24.7 per cent corundum, 1.9 per cent chlorite, and 3.8 per cent garnet, while the heavy mineral fraction of the mantle rock sample contained no corundum, 0.5 per cent chlorite, and 2.8 per cent garnet.

The light mineral fraction of the Florence limestone consisted of 100 per cent chalcedony but the light mineral fraction of sample 2C consisted of 67.8 per cent chalcedony, 4.2 per cent orthoclase, 15.1 per cent plagioclase, and 12.8 per cent quartz.

Geary County, Sample 3C, Series 3

Sample 3C was taken from a mantle rock which overlies the Florence limestone. The recent soils maps indicate this mantle to be residual from the underlying Florence limestone.

The results of this study have shown the residual classification of this mantle to be incorrect.

Mineralogically sample 3C was very similar to the samples of series 1 and sample 2C, but there was no evidence of genetic relationships between sample 3C and the Florence limestone.

The following are some of the minerals which were present in the heavy mineral fraction of sample 3C but which were absent from the heavy mineral fraction of the Florence limestone: basaltic hornblende, epidote, magnetite, muscovite, rutile, sillimanite, and titanite. Chlorite and corundum were present in the Florence limestone, but were not represented in the overlying mantle. In some cases minerals were present in the heavy fraction of the bedrock in higher percentages than in the heavy mineral fraction of sample 3C. The heavy fraction of the bedrock contained 13.3 per cent tourmaline while the mantle rock contained only 4.35 per cent tourmaline.

The light mineral fraction of sample 3C consisted of 72.3 per cent chalcedony, 2.3 per cent orthoclase, 7.4 per cent plagioclase, and 17.8 per cent quartz. The light mineral fraction of the Florence limestone consisted of 100 per cent chalcedony.

Geary County, Sample 4C, Series 4

Sample 4C was taken from the mantle rock overlying the Fort Riley limestone and has previously been mapped as residual from that bedrock formation.

The heavy mineral fraction of the Fort Riley limestone sample was found to consist of 97.1 per cent barite, and 2.9 per cent muscovite. It was thought that the high percentage of barite was probably a local condition, but the absence of any other heavy mineral except muscovite was assumed to indicate a scarcity of heavy minerals in the Fort Riley limestone. The mantle rock overlying the Fort Riley limestone was found to contain the following heavy minerals which were absent from the bedrock: augite and diopside, basaltic hornblende, epidote, chlorite, corundum, garnet, hornblende, kyanite, sericite, titanite, topaz, and zircon.

The light mineral fraction of sample 4C consisted of 60.4 per cent chalcedony, 4.3 per cent orthoclase, 12.2 per cent plagioclase, and 22.6 per cent quartz, while the light mineral fraction of the Fort Riley limestone consisted of 100 per cent chalcedony.

Average Data for Several Sediments of Known Glacial Origin from the Manhattan Area

Harned (9) has made a rather complete mineralogical and mechanical study of some of the glacial sediments of the Manhattan, Kansas area. The average mineral and mechanical analysis data of approximately 100 of the samples studied by Harned are given in Table 3.

A mineralogical and mechanical comparison of the mantle rock from which Geary county samples 1A, 1B, 2C, 3C, and 4C were taken, with the average mineral and mechanical analysis data compiled from a large number of samples of known glacial origin from the Manhattan, Kansas area, indicated a common genesis for the two groups of sediments. Mineralogically the Geary county mantle rocks which were studied were strikingly similar to the average for the many glacial sediments studied by Harned. It was observed that in general the same mineral suites were present in both groups of sediments. The following heavy minerals were found to occur in high percentages in all of the Geary county mantle rock samples and in the glacial sediments of the Manhattan area: epidote, hornblende, magnetite, and muscovite. The minor constituents of the Geary county mantle rock samples were represented in the glacial sediment in percentages similar to those found in the Geary county samples.

The mechanical analysis of the Geary county mantle samples show them to possess a size distribution and degree of sorting which is almost identical to that of the glacial sediments of the Manhattan, Kansas area. The average sorting coefficient for the glacial sediments was 2.04, while the sorting coefficient of Geary county sample 1B was 2.15.

Table 3. Mineral and mechanical analysis data for some samples from Geary County and the Manhattan, Kansas area.

Minerals	1A & 1B	Sh. Wd. Oketo 1C	Sh. Oketo 1D	2C	3C	4C	Fort Riley Ls.	Florence Ls.	Average glacial sediment
					Heavy fraction				
Augite & Diopside	Tr	0.0	0.0	Tr	0.0	Tr	0.0	0.0	1.0
Barite	0.0	0.0	0.0	0.0	0.0	0.0	97.1	0.0	0.0
Basaltic Hbld.	1.7	0.0	0.0	1.1	1.7	1.7	0.0	0.0	2.0
Biotite	Tr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Chlorite	1.3	0.0	0.5	0.5	0.0	0.6	0.0	1.9	5.7
Corundum	0.0	3.4	0.9	0.0	0.0	1.1	0.0	24.7	0.0
Epidote	24.4	0.9	0.5	17.0	16.5	11.3	0.0	0.0	14.6
Garnet	4.2	0.8	2.1	2.8	4.4	2.3	0.0	3.8	4.5
Hornblende	17.7	1.7	2.1	12.6	6.1	4.6	0.0	1.9	19.6
Kyanite	Tr	0.0	0.0	0.8	0.0	0.6	0.0	0.0	1.0
Magnetite	21.5	0.8	1.1	11.9	30.4	26.6	0.0	0.0	18.0
Muscovite	8.1	5.0	4.6	22.5	4.4	5.7	2.9	0.0	8.0
Other Opaques	6.2	0.0	0.0	15.1	21.7	4.3	0.0	39.9	11.8
Rutile	0.0	0.8	0.0	0.0	2.6	0.0	0.0	0.0	0.3
Sericite	4.0	86.2	88.6	5.1	0.0	33.0	0.0	0.0	0.0
Sillimanite	0.6	0.0	0.0	0.8	Tr	0.0	0.0	0.0	1.0
Titanite	3.0	0.0	0.0	0.2	Tr	1.7	0.0	0.0	1.5
Topaz	0.0	0.0	0.0	0.0	0.0	Tr	0.0	0.0	1.0
Tourmaline	3.6	0.0	0.0	3.9	4.4	4.0	0.0	13.3	1.8
Tremotite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0
Zircon	3.6	0.8	0.0	4.4	7.0	2.7	0.0	3.8	7.0
				Light fraction					
Chalcedony	70.5	100.0	100.0	67.8	72.3	60.4	100.0	100.0	24.4
Plagioclase	14.5	Tr	Tr	15.1	7.4	12.2	0.0	0.0	1.8
Orthoclase	4.0	0.0	0.0	4.2	2.3	4.3	0.0	0.0	5.1
Quartz	11.3	Tr	Tr	12.8	17.8	22.6	0.0	0.0	62.9

Mechanical analysis data

Sample	QDa	SKa	SKg^2	Skg	SO	M	Q1	Q3
1B	0.027	0.013	1.160	1.080	2.150	0.030	0.015	0.070
1C	0.017	0.005	0.290	0.540	4.970	0.013	0.001	0.036
1D	0.028	0.006	0.302	0.549	4.190	0.026	0.003	0.060
Av. Glacial sed.	0.022	0.035	0.870	0.880	2.041	0.111	0.092	0.270

SUMMARY AND CONCLUSIONS

In general, field observations alone did not supply sufficient criteria for the determination of the genetic relationships existing between mantle rock and bedrock. The above statement is substantiated by the fact that many of the mantle rocks which were studied have been incorrectly classified on the basis of field observations.

Mineral analysis was found to constitute an excellent criteria for the establishment of mantle rock, bedrock genetic relationships. Mechanical analysis was found to be of considerable value in distinguishing residual mantle from transported mantle; this was particularly true when dealing with sediments of glacial origin.

The mantle rock which composed the terrace along the Smoky Hill River through Russell and Ellis counties has in the past been mapped as residual from the underlying bedrock; however, this material was found to be devoid of mineral and mechanical characteristics necessary to warrant their being classified as residual. Mineral and mechanical studies of these materials indicated them to be of transported origin and the transporting agent was probably fluvial.

The mineral composition of several bedrock formations of Russell county was found to be reflected in the overlying mantle rock. This was considered to constitute an excellent criteria for distinguishing residual mantle rock.

The Geary county mantle rock samples which were studied have recently been mapped as residual from the Florence limestone and the Fort Riley limestone. No mineral or mechanical evidence was found to indicate the presence of genetic relationships between these materials. The mineral and mechanical analysis data for the Geary county mantle rock samples indicated them to be of glacial origin.

The following criteria are suggested as a means of showing the genetic connection between parent material and the overlying mantle rock:

1. The stable heavy minerals present in the mantle rock must also be present in the assigned parent material.

2. The light minerals present in the mantle rock must be such that they could be derived from the minerals of the assigned parent material by known or suspected processes of weathering.

3. If the parent material is thought to be fluvial, laustrine, aeolian or glacial in origin, it should show on mechanical analysis the characteristics of such sediments. The mantle rock derived from such parent material should show the same mechanical analysis data as the parent material except for the effects of weathering.

4. The mechanical analysis of mantle residual on consolidated sedimentary rocks may not resemble that of the parent material very closely.

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