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INSOLUBLE RESIDUE ANALYSIS OF ROCK SAMPLES FROM THE FRANCONIA AND TREMPEALEAU FORMATIONS OF THE CAMBRIAN SYSTEM OF WISCONSIN

by

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PREFACE

During the summer and fall of 1933, a Road Materials Investigation Party spent four months locating road material in northeastern Buffalo County, northeastern Pepin County, and southwestern Eau Claire County. During the investigation a number of prospective quarry developments were located and classified under the general type of sources of shale surfacing for highways. Of these locations samples were taken from 18 different exposures.

An insoluble residue analysis of the rock samples was conducted during the period of time between December 1, 1933 and February 15, 1934. The purpose of the insoluble residue analysis of the rock samples was three-fold:

(1) A study of the insoluble residues to determine the significant relations of the residual material.

(2) A determination of the amount of soluble material.

(3) A quantitative analysis of the balance of soluble material, silt and clay, and sand to ascertain the reason for certain members of the Franconia and Trempealeau formations producing good road surfacing material.

Grateful acknowledgment is made to the Civil Works Administration for the financial assistance which made this report possible; to Mr. R. R. Shrock, of the Geology Department of the University of Wisconsin, for his helpful suggestions, and assistance in field work; to Mr. E.F. Bean, State Geologist, for his advice and aid in furnishing necessary data; and to G. C. O'Connor and R. B. McCormick for their assistance in field work.

E. H. Powell

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INSOLUBLE RESIDUE ANALYSIS OF ROCK SAMPLES FROM THE FRANCONIA AND TREMPEALEAU FORMATIONS OF THE CAMBRIAN SYSTEM OF WISCONSIN

Introduction

The rock samples studied in connection with this report are mainly argillaceous sandstones, dolomites, calcareous sandstones, and silt stones taken from quarries and road cut exposures. A total of 104 samples were run through an insoluble residue analysis. With the exception of 2 samples, from Location 78, Buffalo County, which were taken from the Eau Claire member of the Dresbach formation, the samples were taken from the Franconia and Trempealeau Formations.

The designation of each section by a location number (Location 36, Pepin Co.) is in keeping with the method of reference numbers used by the Road Materials Parties of the Geological Survey of the State of Wisconsin, to identify prospective developments of sources of road material.

A map of the area investigated in connection with this report, showing the location of the exposures sampled in respect to land lines, major highways and principal towns will be found on Plate I.

Procedure

Sampling:

The samples analyzed were taken in a vertical exposure at each of 18 locations. These samples were taken as representative of certain beds or units of rock which differed from those beds above and below. If there were marked irregularities in any one unit, several samples were taken to show the changes.

Laboratory Procedure.

The preliminary work consisted in numbering each rock sample, the numbers ranging from 1 to 102; these numbers were then placed on form sheets like the one on page 5. These form sheets were then made into a catalogue in which all necessary data obtained could be recorded. Trial tests were then made on a number of small rock samples to see if hydrochloric acid would break the sample down enough to separate the sand from the silt and clay sample. These trial tests showed that crushing of the samples was necessary to get a clean separation of the insoluble residue.

To obtain uniformity of results, all samples were crushed down to small fragments or, in the case of argillaceous sandstones, to granular size. (While the crushing of the sample is apt to break down some of the sand grains, the necessity of a clean separation in the residue is so urgent that this method was used.)

After crushing, the sample was weighed out into a smaller sample of 50 grams and placed in a numbered 250 cc beaker of known weight. A battery of 12 samples was run at a time. To each of the 50 gram samples, 75 cc of 1 to 1 Hcl. was added. The battery of beakers was then set on a warm radiator and left for from 12 to 18 hours. During the time the acid was working on the samples, they were stirred occasionally and more acid added if necessary, until all action ceased. The first battery of beakers was removed from the radiator and another battery prepared in the same manner replaced it.

The first battery of beakers was then allowed to cool until the beakers could easily be handled. All of the acid that could be poured from the beakers without losing any of the insoluble residue in the bottom, was poured off. Then the residue was rinsed three times to remove all acid and acid salts. The residue was rinsed in lake water to prevent flocculation of the clay. After

each rinsing the beaker was left standing until all clay and silt had settled to the bottom. On pouring off the water from the residue, care was used so that none of the residue was permitted to go out with the water. After the third rinsing, as much of the water was poured off as could be safely removed.

The battery of beakers containing the insoluble residue from the samples, was placed in an electric oven under 110° C of heat. The residue was left in the oven from 10 to 12 hours until it was thoroughly dried. The beakers containing the residue were weighed and the weight of the residue from each sample calculated and recorded on the proper record sheet in the catalogue.

After drying, the residue usually had a hard, baked cake of clay and silt, as a cracked crust on top. A general examination of this crust was made at this time to determine the physical character of the clay and silt. The cake was then removed from the beaker and ground down to a fine powder in a porcelain mortar. The powder was dumped back into the beaker with the residue of sand; distilled water was then added to the residue and stirred well. This solution was allowed to settle for approximately 30 seconds, then the water containing the silt and clay was poured through a 200 mesh screen (1/13 mm openings,) which showed no difference in openings under a microscope magnifying 20X. The operation of adding distilled water to the residue and pouring the water carrying the silt and clay was repeated until all the silt and clay was removed. During the wet washing of the clay and silt through the 200 mesh screen, it was necessary to tilt the screen and wash it down repeatedly with a wash bottle to prevent the screen from clogging. After the last of the silt and clay was washed through the screen, the screen was turned upside down in a 500 cc beaker and all of the sand retained on the screen washed into the large beaker. The sand left in the small beaker was then washed into the large beaker; the water was poured off the sand, and the sand washed out of the large beaker

onto a numbered 3½' watch glass of known weight. (The clay and silt were not saved.)

The sand residue was dried in the watch glass on the radiator for about 3 hours until it was thoroughly dry. After drying, it was weighed, the weight of sand claculated and recorded on the proper record sheets in the catalogue.

The sand was then removed and placed in small numbered envelopes to await microscopic inspection.

After all the samples had been put through the above procedure, the residue sand was examined under a binocular microscope which magnified 20X. All the salient characteristics of the sand were put in their proper places on the record sheets.

A hand lens examination of the sample had been made before the first crushing and the resultant character placed on the record sheets.

Finally the percentages of soluble material, clay and silt, and sand were calculated and placed on the record sheets. (See sample record sheet, page 5.)

From the data on the record sheets and field data from the field notes of the Road materials investigations, Plates 1 to 20 were made.

Sample #1

Insoluble Residues

Location: Eau Claire County, 100 yds. W and just S of the center of the NW ¼ of Sec. 35, T.25N., R.10W.

Horizon: 100' above $\frac{Qf}{Oi}$

Watch Glass Number 10 — Beaker #10

Wight of Sample and Beaker _____ — Weight of Residue 21.92

Weight of Beaker 20.28 grs. — Weight of Clay 3.02

Weight of Sample 30.00 grs. — Weight of Sand 18.90

Weight of Residue and Glass 97.97 — Weight of Clay 3.02

Weight of Glass 74.05 — % Clay 10.07%

Weight of Residue 21.92 — Weight of Sample 30.00

Weight of Residue and Glass 42.20 — Weight of Sand 18.90

Weight of Sand and Glass 39.18 — % Sand 63.00%

Weight of decanded Clay 3.02 — Weight of Sample 30.00

% Residue 73.07%

%Insoluble 26.93%

Description

Of Sample: Sample crushed to granular size.
A light buff to yellow, fine-grained, well cemented sandstone containing 1/3" to 1/4" bands of iron-stained sandstone which is reddish-brown in color.

Of Residue: A very fine to fine sand (probably quartz), mainly subangular but with some angular and rounded grains present. The more rounded grains are frosted. Glauconite 1% to 2% -- grains dark green, polished and rounded. A few aggregates of quartz crystals and a few iron-stained sand grains present.

System	FORMATION	MEMBER	CHARACTER
QUATERNARY	Glacial Outwash		Silt, sand, clay and gravel in river outwash.
ORDOVICIAN	St. Peters		Sandstone, moderately coarse well-cemented grains frosted (0'-20')
	Lower Magnesian		Dolomite, gray to light buff, thick and thin beds, cryptozoa, oolites and chert present. Sparsely fossiliferous. (0'-130')
CAMBRIAN	Trempealeau	Madison	Generally absent
		Jordan	Sandstone, medium to fine grains, yellow to brown, massive to thin beds. (30'-100')
		Lodi	Sandstones, siltstones, and dolomites. A calcareous unit, thin beds, fine even texture, some shale. Fossiliferous. (12'-26')
		St. Lawrence	Dolomite. Thin bedded, well crystallized, sand, buff splotched with purple or pink. Fossiliferous. (2'-6')
	Trempealeau or Franconia (2)	St. Lawrence or Franconia (?)	Calcareous sandstone, and siltstone also dolomite. Thin wavy beds with shale partings, large worm trails abundant in green shale partings. (6'-15')
	Franconia		A series of thin to thick beds of green sand, glauconitic sandstone, argillaceous sandstone with minor shale beds. Gray, green, buff, white and brown. Fossiliferous. (100-170')
	Ironton		Sandstone, reworked, fossiliferous, coarse, ironstained. (15'-40') ?
	Dresbach	Galesville	Sandstone, fine to medium grained, thick bedded, mottled white-brown. 40' +
		Eau Claire	Sandstone and shale. Thin bedded, fossiliferous, argillaceous, gray. 40' +

General Stratigraphy of Area Investigated

The Geologic Column of the area on page 6 gives a skeleton framework of the general stratigraphy of the area investigated in connection with this report. Of the formations and members in the column this report is concerned only with the Franconia and Trempealeau formations, and the Eau Claire member of the Dresbach formation.

The Eau Claire Member of the Dresbach

In the vicinity of Mondovi and Gilmanton, the Eau Claire member of the Dresbach formation forms the low flat topped terraces in the valley bottoms of the Buffalo River and Elk Creek. The maximum exposure is 40' thick. The greater part of the exposure consists of thinly bedded, fine grained, silty, gray sandstones which are heavily fossiliferous. In the Elk Creek valley, east of Gilmanton at Location 73, 10' down from the top of the Eau Claire member is an 8' to 10' unit of inter-bedded, fine-grained, thinly-laminated sandstone and green shale. This unit can be used for road surfacing. See Plate XV for details concerning the unit.

The Franconia Formation

The Franconia formation ranges from 100' to 170' thick, forming the large intermediate uplands of the region. The formation is composed of heavy bedded units of green sand, thinly bedded units of mottled argillaceous sandstone, and thinly laminated units of gray-green, sandy shale. The members of this formation change in thickness and character laterally; therefore the only logical basis for a separation into members is a paleontological one. The formation is abundantly fossiliferous, glauconitic throughout, and contains

mica flakes, especially in the lower 40'. Ranging from 10' to 27' above the base of the formation, a hard, well cemented, glauconitic, iron-stained, well crystallized, brown bed of either dolomite or limestone appears over the area investigated.

The Questionable Member

This member is from 6' to 15' thick. It lies between the massive upper greensand of the Franconia formation and the base of the St. Lawrence dolomite member of the Trempealeau formation. The member consists of a thin bedded series of buff calcareous sandstones, and silt stones; with thin green shale laminae, crossed and recrossed by large worm trails, lying along bedding planes. (See Plates IV, IX and XVII) Invariably there is a 2'-4' bed of highly dolomitized green sand conglomerate, containing discoidal buff dolomitepebbles, at the base of the questionable member. This unit is a compact member in itself. It has physical characteristics of the St. Lawrence member above yet differs markedly. The heavy greensand conglomerate at the base tends to throw the member into the base of the Tremealeau formation, yet there is also a conglomerate at the base of the St. Lawrence which might mark that horizon as the base of the T rempealeau Formation.

At present the position of this member is in question. A study of the fauna of the member is necessary to definitely determine to which of the two formations it belongs.

The St. Lawrence Member

The St. Lawrence member of the Trempealeau formation is from 2' to 6' thick. It is a thin to medium, unevenly bedded unit of sandy, well crystallized, unevenly textured buff dolomite usually mottled with pink or purple.

The dolomite is usually slightly glauconitic, and often contains thin laminae of green shale along bedding planes. The lower beds of the member are often conglomeratic, containing small rounded, flat pebbles of sandy dolomite or dolomitic sandstone in a matrix of buff dolomite. Fossils are often present but not abundant. The fossils are usually trilobites, brachiopod, and graptolite remains.

The Lodi Member

The Lodi member of the Trempealeau formation ranges from 12' to 26' ± thick. Usually it is a thinly and regularly bedded series of calcareous sandstones, calcareous silt stones, and silty dolomites, with thin laminae of green shale present, especially in the basal 6' of the member. The color of the rock usually is buff, gray, or gray-green. Except in the cases where pure sandstone occurs the physical character of the beds changes but slightly. The siltstones and dolomites are especially alike in hand samples. The thin beds of this member usually fracture into fairly regular blocks and slabs from 2" to 8" over their long dimensions.

The Jordan Member

The Jordan Member of the Trempealeau formation has little bearing on this report save that the basal 1' to 4' is usually a highly fossiliferous, dolomite or dolomitized sandstone which can be used as road surfacing.

PLATES
and
PLATE DESCRIPTIONS

PLATE I

Figure I - An outline map of Wisconsin showing the position of the area investigated in connection with this report.

Figure II - A base map of the area investigated, showing the position of the locations in respect to principal towns, land lines, and important highways.

PLATE II

Location 51, Eau Claire County

Plate II shows a 13' section of Franconia sandstone exposed in a road cut. The greater part of the exposure is a thinly bedded, mottled gray, green and buff, glauconitic, argillaceous sandstone. The base of the section is 100' above the base of the formation.

Insoluble Residue Analysis (Samples 1-4)

With the exception of sample 1, the balance of material is:

Soluble content - 3.17% to 5.34%
Silt, clay content - 4.77% to 17.87%
Sand content - 77.06% to 92.06%.

The microscopic character of the sand residue is in general: a very fine to fine sand (probably quartz). . . Grains are frosted to clear. Glauconite 2% in polished, rounded, dark and light green grains. No mica plates or quartz crystals noted.

Economic Aspects

The rock exposed in the road cut has been used as surfacing on light traffic roads. The material has proven satisfactory for this purpose for a period of 3 years on a clay sub grade. The great bulk of sand in this exposure makes it doubtful that the material removed would stand up under heavy or medium traffic, or under light traffic on a sand subgrade.

Under ordinary circumstances this material could be used for surfacing shoulders along concrete highways and on light traffic roads with a clay subgrade.

PLATE III

Location 36, Pepin County

Plate III shows a 13½' section of Franconia sandstone, shale and dolomite taken in a quarry just east of the Charles Shriner barn. The base of the section is 10' ± above the base of the Franconia formation. The section is thinly bedded, and in the main an argillaceous, glauconitic mottled sandstone.

Insoluble Residue Analysis (Samples 5-10)

With the exception of Sample 9 which is 79.67% soluble, the balance of material is:

Soluble content -	6.84%	to	26.14%
Clay, Silt content -	8.80%	to	22.83%
Sand Content -	65.06%	to	82.95%

The microscopic character of the residue sand is: A fine, angular to rounded, frosted to clear sand (probably quartzite) containing from 5% to 10 % glauconite. Sample 6 shows more frosting and less glauconite than the others. Sample 9 is about 90% glauconite, 50% of which is badly altered. Sample 10, at the top of the section, shows the first appearance of mica flakes.

Economic Aspects

The rock from this quarry has been used to patch low places in the German Valley Road. It apparently stands up well in wet places, and under light traffic, binds well. While this material has not been thoroughly tested by actual use, it has enough binding material to stand up as surfacing on light traffic roads, or as shoulder surfacing along concrete highways.

PLATE IV

Location 37, Pepin County

Plate IV shows an exposure in a road cut and quarry on the north side of C.T.H. "W". The exposure includes the Questionable member, the St. Lawrence member, the Lodi member and 13½' of the base of the Jordan member. In general it is made up of thinly bedded sandstone, siltstone and dolomite.

The Questionable Member (10')

Insoluble Residue Analysis (Samples 13-14)

The four feet of greensand conglomerate at the base of the questionable member was not sampled. Samples 13 and 14 taken from the upper 6' of the member show the following balance of materials:

Soluble content	-	11.84%	to 40.10%
Silt, Clay content	-	7.63%	to 11.75%
Sand content	-	48.17%	to 80.16%.

Microscopic Character of Sand Residue

In main a very fine to fine clear angular sand (probably quartzite) containing fragments of quartz crystals and a few transparent mica flakes.

The St. Lawrence Member (6')

Insoluble Residue Analysis (Samples 15-16)

The balance of materials in the St. Lawrence member is:

Soluble content	-	47.87%	to 77.40%.
Silt, clay content	-	3.66%	to 5.80%.
Sand content	-	18.80%	to 48.47%.

Microscopic Character of the Sand Residue

A fine to very fine, angular, clear sand (probably quartz). About 10% normal quartz crystals. Glauconite less than 1%. Mica flakes rare.

Lodi Member

Insoluble Residue Analysis (Samples 17-21)

The balance of materials in the Lodi member is:

Average soluble content - 47%
Average silt, clay content- 19%
Average sand content - 34%.

Microscopic Character of Sand Residue

A fine, clear, angular sand (probably quartz). No frosted grains. Samples 18 and 20 show a chert sand. Sample 17 and 21 contain quartz crystals. Samples 19, 20, 21 show mica flakes. Sample 21 is unique in having an exceptionally large number of quartz crystals present.

Jordan Member

Little need be said about the two samples (22 and 23) taken from this member. They are predominantly sand, containing very little soluble material.

The sand is usually angular to sub-angular. Mica flakes are present in small amounts. Quartz crystals, both whole and fragmentary are common.

Economic Aspects

Some rock has been removed from this location, but only from the Questionable and St. Lawrence members, and used for patching the surface of C.T.H."W". No record of service was obtained. An examination of the balance of soluble material, silt and clay and sand in the Questionable, St. Lawrence, and Lodi members exposed at the location makes it apparent that this material will be good for surfacing light and medium traffic roads, the soluble material and silt and clay making up more than 50% of the rock.

Plate V

Location 40, Pepin County

Plate V shows a section taken of a roadcut exposure on the N side of C.T.H."A". 11' of mottled argillaceous Franconia sandstone are exposed. The base of the section is about 12' above the base of the Franconia formation.

Insoluble Residue Analysis (Samples 24-25)

The balance of material in the analysis is:

Soluble content	-	4.9% to 9.57%
Silt, clay content	-	13.9% to 23.80%
Sand content	-	66.63% to 81.20%

Microscopic Character of Sand Residue

A fine angular to subangular sand, (probably quartz) containing a few quartz crystals and siliceous oolites with occasional mica plates.

Economic Aspects

The material taken from this cut was used for patching C.T.H."A". This surfacing has stood up well under light traffic for four years. The amount of sand is high but the material will probably serve adequately as surfacing for light traffic roads like C.T.H."A".

PLATE VI

Location 41, Pepin County

Plate VI shows a section taken of an exposure in a road cut on the north side of C.T.H."A". 10½' of argillaceous, mottled, Franconia sandstone in the section, the base of which is 10' above the base of the Franconia formation.

Insoluble Residue Analysis (Samples 28-29)

With the exception of sample 26, the balance of materials is:

Soluble content	- 6.14%	to	10.90%
Silt and clay content	17.57%	to	29.60%
Sand content	- 61.10%	to	71.53%.

Sample 26, a sandy glauconitic limestone or dolomite is from the same unit as sample 9 of Plate III and sample 50 of Plate XIII. This sample has 58.52% soluble content, 3.57% silt and clay content, and 38.16% sand content.

Microscopic Character of the Sand Residue

Sample 28 shows a sand residue of fine angular to rounded grains, (probably quartz) containing many round grains which appear to be siliceous oolites but which are probably glauconite grains altered to a gray-white in color by weathering and acid action. Sample 27 shows a fine rounded sand of equal amounts of frosted quartz and chert. Mica flakes are present but not common. Samples 28-29 show fine to very fine angular to rounded, frosted sand grains (probably quartz). Slightly rounded quartz crystals are common, mica flakes occasional. Glauconite is usually about 1% ±. Siliceous oolites appear in Sample 29.

Economic Aspects

The only material removed from this location for use as road surfacing was taken out when the road cut was made. This material has been graded down

the hill slope to the east from the road cut. This part of C.F.H."A" has stood up well under light traffic, the surface binding to furnish a hard smooth surface. Observed after a soaking rain, the road surface was hard and firm. (Not slippery). Apparently the material exposed in the cut has enough binder in the form of clay, silt and soluble material to make a better type of road surfacing than that at Location 40. The material is considered suitable as a source of road surfacing for light traffic roads or on shoulders along concrete highways.

PLATE VII

Location 42, Pepin County

Plate VII shows an 11½' section of siltstone dolomite and sandstone exposed near the top of the Lodi Member of the Trempealeau formation. The exposure is in a road cut on the S side of C. T. H. "A". The entire exposure is thinly bedded, and broken into blocks and slabs by weathering. The dolomitized siltstone and silty dolomite exposed in the road cut have the same general physical characteristics, being fine-grained, evenly-textured, thinly bedded, similar in color and of about the same hardness and toughness. The dolomitized sandstone is apt to be more sandy in appearance than the siltstones or the dolomite.

Insoluble Residue Analysis (Samples 30-38)

The balance of materials in the rock exposed in the road cut is:

Soluble content -	41.70%	to	56.67%.
Silt and clay content	21.80%	to	46.43%.
Sand Content -	.53%	to	36.50%.

The sand content is much lower than the upper limits of the range indicates usually being below 10%.

Microscopic Character of the Sand Residue

All of the residues except sample 30 show the same general character. The sand is very fine to fine grained, clear and angular (probably quartz). Glauconite constitutes 3% of the sample, mica flakes are common; fragmentary crystals of quartz are present but rare. In sample 30 glauconite is absent, mica flakes are absent, quartz crystals are abundant.

Economic Aspect

No record of the use or service of the material taken from the cut was obtained. Other similar exposures have been used within the area investigated

as road surfacing with good success. The high soluble content and silt and clay content show that the material has a good supply of binder plus enough cementing material to give good rock bulk and still develop into a smooth road surface. The material in this location should prove satisfactory as a source of all weather surfacing for light and medium traffic roads.

PLATE VIII

Location 64, Buffalo County

Plate VIII shows a 14½' section of bed rock exposed in a quarry. The section includes the questionable member, the St. Lawrence Member of the Trempealeau formation and 1½' of weathered material from the base of the Lodi member of the Trempealeau formation.

The Questionable Member (7½')

Insoluble Residue Analysis (Sample 34)

The balance of material in this compact unit of calcareous siltstone is:

Soluble content - 38.4%
Silt and Clay content 50.7%
Sand content - 10.9%.

Microscopic Character of the Sand Residue

A fine, clear, angular sand (probably quartz) containing rare grains of glauconite and occasional flakes of mica.

The St. Lawrence Member (5½')

Insoluble Residue Analysis (Samples 35-36)

The balance of materials in this unit is:

Soluble content	- 61.93%	- 67.30%
Silt, Clay content	- 17.44%	- 23.57%
Sand content	- 9.13%	- 20.63%

This unit is a rather soft dolomite but carries the true physical character of the St. Lawrence.

Microscopic Character of the Sand Residue

A very fine, well sorted, clear, angular sand with occasional quartz crystals, 0% to 2% glauconite and rare mica flakes.

Economic Aspects

The rock removed from this quarry was used to surface part of the Thompson Valley road 9 years ago. The surfacing has stood up well in wet, low places and on badly washed hill slopes, under light traffic. The high binder content plus the rock bulk present should make this material serviceable as all weather surfacing on either light or medium traffic roads.

PLATE IX

Location 66, Buffalo County

Plate IX shows a section taken in the Fitzgerald quarry, exposing 14½' of the Questionable member, 4-3/4' of the St. Lawrence Member of the Trempealeau formation and 4½' of the Ladi member of the same formation. Samples were not taken from the Ladi member.

The Questionable Member (14½')

Insoluble Residue Analysis - (Samples 37 - 42)

The balance of materials in this compact member is:

Soluble content	=	42.67% to 57.90%.
Silt, Clay content	=	5.54% to 46.87%.
Sand content	=	10.46% to 57.03%.

A good balance of materials with a high soluble content.

Microscopic Character of the Sand Residue

Samples 37-39 taken from the lower 5' of the member all show a sand composed of fine, angular to rounded, frosted grains (probably quartz); containing 25% to 30% glauconite. Occasional mica flakes in samples 38 and 39; some quartz crystals in sample 39.

Samples 40,41, and 42 show extremely fine, angular, clear sand (probably quartz) containing occasional mica flakes and rare grains of glauconite.

The St. Lawrence Member (4-3/4')

Insoluble Residue Analysis (Samples 43-44)

The balance of materials in this dolomite unit is:

Soluble content	=	65.20% to 71%
Silt, Clay content	=	10.23% to 13.73%
Sand content	=	18.77% to 21.07%

A true St. Lawrence dolomite having a rather high sand and silt content.

Microscopic Character of Sand Residue

The sand is very fine, translucent and angular. (probably quartz). Flake mica and quartz crystals common. Glauconite 2%.

Economic Aspects

The rock removed from this quarry has been used with success over short stretches of State Trunk Highways 68 and 37, as surfacing material. No accurate reports as to length of service of the material were obtained; just a report of general satisfaction of the material as all weather surfacing. The entire face in the quarry has a good balance of soluble material, clay and silt, and sand. For light and medium traffic roads this material should be a good all weather surfacing material. It has sufficient binder and rock bulk to give a good wearing surface.

PLATE X

Location 67, Buffalo County

Plate X shows a 14' section of Franconia sandstone exposed in a road cut on both sides of Steele Valley road. The base of the section is approximately a 65' above the base of the Franconia formation.

Insoluble Residue Analysis (Sample 45-46)

The balance of material in this unit of the argillaceous sandstone is:

Soluble content	-	5.37%	to	74.2%
Silt, Clay content	-	14.7%	to	22%
Sand content	-	38.0%	to	72.7%

Of the two units sampled in this exposure, the lower one has a much greater soluble content than the upper one. The upper is higher in silt and clay content.

Microscopic Character of Sand Residue

A fine, angular to rounded sand (probably quartz) showing some frosting. Glauconite from 2% to 8%. Fragmentary quartz crystals present in basal unit. Mica flakes occasional to common.

Economic Aspects

Rock from this cut was used on the light traffic Steele Valley town road as patching for surfacing. The surfacing has stood up well under such traffic. The balance of materials in the quarry shows a fair proportion of sand, silt, and clay and soluble material; for light traffic roads this location should produce material for for all weather surfacing.

PLATE XI

Location 68, Buffalo County

Plate XI shows a 11½' section of Franconia sandstone exposed in a quarry on the N side of County Trunk Highway A. This location is very much like that on Plate X except that the insoluble residue analysis shows less soluble material and more sand. The microscopic character of the sand is much the same.

Economic Aspects.

The rock removed from this quarry was used to surface the West end of C.T.H."A" and the N end of C.T.H."J" five years ago. The material has proved satisfactory over that period of time packing well and presenting a smooth surface which does not get slippery or soft in wet weather. Although the sand content is high, the material exposed in this location, should prove satisfactory as surfacing material on light traffic roads.

PLATE XII

Location 72, Buffalo County

Plate XII shows 21½' of Franconia sandstone and sandy shale exposed in a quarry a nd road cut on both sides of S.H."88". The base of the section is 33' above the base of the Franconia formation.

Insoluble Residue Analysis (Samples 50-54)

With the exception of Sample 50, the balance of material is as follows:

Soluble content	-	2.9% to 9.4%.
Silt and Clay content	-	10.6% to 35.8%.
Sand content	-	57.4% to 77.9%.

The soluble content of the samples is uniformly low. The silt and clay content moderate, the sand content high. Sample 50 is a limestone or dolomite with a soluble content of 70.7%, a silt and clay content of 2.3%, and a sand content of 27.0%.

Microscopic Character of the Residue Sand

The sand in sample 50 is 50% fine, rounded frosted quartz grains and 50% dark green glauconite grains. No mica flakes. Samples 51-54 show a very fine to fine, angular to rounded, frosted sand (probably quartz). Glauconite in occasional grains; mica flakes occasional except in Samples 51 and 54 where they are absent. Sample 51 contains small rhomboidal crystals showing cleavage which are probably feldspar.

Economic Aspects

The rock removed from the cut and quarry was used to surface S.T.H.#88, 5 to 8 years ago. At that time, overlying beds of greensand were used with the material shown in the section on Plate XII. The use of this poor quality greensand makes an accurate determination of the serviceability of the material impossible. With the greensand in it the surfacing material

proved satisfactory as long as a wear coat of gravel or crushed limestone covered it. In late years the wear coat has been disappearing. At present the road surface is breaking up rapidly. Although the soluble content in this exposure is low, and the sand content is high, it is apparent that this material will be suitable surfacing for S.T.H.#33 if a wear coat of crushed limestone or gravel is kept on the surface of the road.

PLATE XIII

Location 74, Buffalo County

Plate XIII shows 18' of the St. Lawrence and Lodi Members of the Trempealeau formation exposed in a road cut on the W side of a town road.

St. Lawrence Member (5')

Insoluble Residue Analysis (Samples 55-56)

The balance of materials in this typical St. Lawrence dolomite member is:

Soluble content	-	48.1%	to 74.6%.
Silt and Clay content	-	11.0%	to 18.6%
Sand content	-	14.3%	to 33.3%

Microscopic Character of Sand Residue

A fine, angular, clear sand (probably quartz) containing occasional mica flakes, rare glauconite grains and a few whole and fragmentary quartz crystals.

Lodi Member (13')

Insoluble Residue Analysis (Samples 57-60)

The balance of materials in this member is:

Soluble content	-	35.9%	to 63.8%
Silt, Clay content	-	9.1%	to 45.4%
Sand content	-	5.1%	to 42.1%.

Microscopic Character of Residue Sand

A clear, very fine, angular sand (probably quartz) containing rare mica flakes and a few fragmentary quartz crystals. Sample 59 shows a white chert sand containing 1% glauconite.

Economic Aspects

No service record of material removed from this cut for use as road surfacing was obtained; however, the high soluble carbonate content and the moderately high silt and clay content reveals this material to be of a type which will have rock bulk for wear and at the same time have enough

binding material to present a smooth all weather road for light or medium traffic roads and shoulder surfacing along concrete highways.

PLATE XIV

Location 76, Buffalo County

Plate XIV shows a section of 22' of Franconia green sand and argillaceous sandstone exposed in a quarry on the W side of C.T.H."H". The base of the section is 65' above the base of the Franconia formation.

Insoluble Residue Analysis (Samples 98-102)

With the exception of Sample 102, which was taken from the upper green sand unit, the balance of material is:

Soluble content	-	6% to 18.8%.
Silt, Clay content	-	16.3% to 24.1%.
Sand content	-	63.4% to 76.7%.

Sample 102 is an aggregate of 3 samples taken from the 6' green sand unit at the top of the quarry exposure. See Sample 102, Plate XIV for details.

Microscopic Character of Sand Residue

Generally a fine to very fine, angular to rounded, frosted sand, (probably quartz) containing 6% to 30% glauconite; mica flakes occuring rarely or occasionally.

Economic Aspects

The rock removed from this quarry has been used for surfacing parts of C.T.H."H"[1] Five years ago this surfacing was put on the road and much of the poor quality upper green sand was used. This surfacing has stood up for five years under light traffic, but at present is soft in the wet seasons and ruts develop. During the summer it furnished a hard smooth surface for the first three years. A better service record would probably have been obtained on this road if the upper greensand unit had not been used. This quarry, if properly worked should furnish a fair all weather surface on light traffic roads.

PLATE XV

Location 78, Buffalo County

Plate XV shows a 6½' section of Eau Claire shale and sandstone exposed in a quarry on the North side of C.T.H."B". The top of the section is 15' below the top of the Eau Claire member of the Dresbach Formation.

Insoluble Residue Analysis (Samples 61-62)

The balance of material in the two samples taken from the quarry exposure is:

Soluble content	-	8.1% to 8.2%
Silt and clay content	-	27.0% to 29.0%
Sand content	-	62.9% to 64.8%

Microscopic Character of the Sand Residue

A fine angular to rounded quartz sand containing larger fragments of chert. Rounded quartz grains frosted. Mica flakes occasional.

Economic Aspects

The rock removed from this quarry has been used to patch low, wet places in C.T.H."B". It has stood up well in these places as surfacing for a light traffic road.

PLATE XVI

Location 79, Buffalo County

Plate XVI shows a 9½' section of argillaceous Franconia sandstone exposed in a quarry. Base of the section is 27' above the base of the Franconia formation.

Insoluble Residue Analysis (Samples 63-63a)

The balance of materials is:

Soluble content	-	3.5% to 17.3%.
Silt, Clay content	-	19.3% to 21.4%
Sand content	-	61.3% to 76.8%.

Microscopic Character of Sand Residue

A very fine to fine, angular to subangular clear to frosted sand, probably quartz, containing 2% glauconite and occasional mica flakes.

Economic Aspects

The rock from this quarry was used on light traffic town roads with fair success as a surfacing material. The material is fitted only for surfacing on light traffic roads.

PLATE XVII

Location 84, Buffalo County

Plate XVII shows a section of 37' of bed rock exposed in a road cut and quarry on the west side of State Trunk Highway 88, where the road climbs the north side of Gilmanton Ridge. The complete sections of the Questionable Member, the St. Lawrence Member, the Lodi member, and the basal 3' of the Jordan member are exposed at this location. In the Lodi member, the siltstones, calcareous sandstones, and silty dolomites all have the same physical appearance in a hand specimen.

The Questionable Member (14')

Insoluble Residue Analysis (Samples 64 - 66)

The balance of materials is as follows:

Soluble content -	6.9%	to	48.2%
Silt, Clay content	20.8%	to	49.6%
Sand content -	10.2%	to	43.5%

Microscopic Character of the Sand Residue

An extremely fine, clear, angular sand (probably quartz) with occasional mica flakes and rare grains of glauconite present.

The St. Lawrence Member (2')

Insoluble Residue Analysis (Samples 67 - 68)

The balance of materials for this member is:

Soluble content -	47.7%	to	68.8%.
Silt and Clay content	18.2%	to	21.2%
Sand content -	31.1%	to	31.8%.

Microscopic Character of Sand Residue

Like that in the Questionable Member only more glauconite.

Lodi Member (15')

Insoluble Residue Analysis (Samples 69-74)

The balance of materials in this member is:

Soluble Content	-	43.1% to 66.5%
Salt and Clay content		20.1% to 49.5%
Sand content	-	1.5% to 46.2%

A unit of dolomite, silt stone and calcareous sandstone.

Microscopic Character of Sand Residue

Extremely fine to very fine, angular, clear sand (probably quartz) containing 1% to 6% glauconite and occasional to common mica flakes. Sample 72 is mainly a white chert sand.

The Jordan Member

(See Plate XVII)

Economic Aspects

Rock from the Questionable and St. Lawrence Member has been used as surfacing material on part of State Trunk Highway 66. This material has worn well under the light to medium traffic of this road but has been rough and very hard to grade down to a smooth surface in dry seasons. The rock bulk is good but has also been slow the release of binder slow. Surfacing material has also been obtained from the Lodi member to use in patching S.T.H.#66. This surfacing material has proved satisfactory because it retains rock bulk while at the same time the binder material is released to form a smooth top surface, thereby furnishing an all weather road surface. Of the entire section, the Lodi member with its high soluble, and silt and clay content has proven the most satisfactory as a source of surfacing for light and medium traffic roads.

PLATE XVIII

Location 86, Buffalo County

Plate XVIII shows a section of 21½' of bed rock exposed in a quarry and road cut. The exposure includes most of the Questionable Member, all of the St. Lawrence member, and the basal 5' of the Lodi Member.

The Questionable Member (13½')

Insoluble Residue Analysis (Samples 77-83)

The balance of materials in this member is:

Soluble content	-	6.9%	to 57.9%
Silt and Clay content	-	13.2%	to 49.6%
Sand Content	-	12.4%	to 48.6%

Microscopic Character of Residue Sand

An extremely fine to very fine, clear angular sand (probably quartz) containing occasional quartz crystals, rare to common mica flakes, and rare occurence of glauconite grains at the base of the member. In samples 77 and 79, there is some frosting of grains.

The Lodi Member (5')

Insoluble Residue Analysis (Samples 86-87)

The balance of materials in this basal unit of the Lodi member is:

Soluble Content	-	31.2%	to 61.7%
Silt and Clay content	-	22.4%	to 37.9%
Sand content	-	.3%	to 46.3%

Microscopic Character of Sand Residue

A very fine, angular to sub angular sand (probably quartz) containing occasional quartz crystals, mica flakes and grains of glauconite.

Economic Aspects

Although the rock from this quarry has been used for surfacing on light traffic roads in the vicinity, no record of service was obtained. The balance of the soluble material silt and clay, and sand points to a good all weather surfacing for light traffic roads.

PLATE XIX

Location 90, Buffalo County

Plate XIX shows a 38' section of bed rock exposed in a road cut. The exposure includes the upper 5' of the Questionable Member, all of the St. Lawrence and Lodi Members and 4' of the base of the Jordan member of the Trempealeau formation.

THE QUESTIONABLE MEMBER (5')

Insoluble Residue Analysis (Sample 89)

(See Sample 88, Plate XIX)

St. Lawrence Member (6')

Insoluble Residue Analysis (Samples 89-91)

The balance of material in this dolomite member is:

Soluble content	-	65.8%	to	70.7%
Silt, Clay content	-	11.5%	to	14.1%
Sand content	-	16.6%	to	20%

Microscopic Character of Sand Residue

A very fine to fine, angular to rounded sand (probably quartz). Grains show frosting. Sand contains occasional quartz crystals and mica flakes; glauconite rare to 5% of sand.

Lodi Member (26')

Insoluble Residue Analysis (Samples 92-96)

This member is mainly a silty dolomite with a balance of material as follows:

Soluble content	40.3%	to	62.9%
Silt and clay content	22%	to	54.2%
Sand content	2.1%	to	37.6%.

In most of the samples the sand content is below 4% and the silt and clay content over 34%.

Microscopic Character of Sand Residue

The sand is generally like that of the St. Lawrence member below.

Economic Aspects

No service record for the material from this location was found. The Lodi member is largely a silty dolomite which contains both rock bulk and an abundance of binder. It should prove to be a successful surfacing material for light and medium traffic roads.

PLATE XX

A CORRELATION CHART

SUMMARY

General Description of the Insoluble Residue

The insoluble residues obtained from the samples studied in connection with this research problem were classed into two general types:

(1) Clay and silt,

(2) Sand.

The clay and silt residue from the samples was given a general examination mainly because the clay and silt serve in the same capacity as binder in road surfacing materials. The general examination of this type of residue was made when the residue was in a dry state. This residue was usually gray to buff in color but sometimes green or brown. This residue was seldom flaky, usually being finely divided and having a tendency to pack on drying. Upon stirring the residue in water, it settled slowly, but rarely showing any appreciable amounts of colloidal material. The bulk of clay and silt in the samples was found in those samples taken from the Lodi member of the Trempealeau formation.

The sand constituted the remainder of the insoluble residue. This sand was examined under a binocular microscope which had a magnification of 20X.

In general the sand is extremely fine to fine, angular to rounded, clear or frosted, (probably quartz). Many of the residues contain glauconite ranging up from a fraction of 1% to 50%. The glauconite greens range from an altered gray-white to dark green in color. Many of the grains retain their original shape presenting shiny curved surfaces, or in the case of aggregates of more than 2 grains, a shiny botryoidal surface. A large number of the glauconite grains from the residues of the Trempealeau formation are

fragmentary and worn down on the edges. Certain residues were mainly white chert. Transparent mica flakes are present in a large number of the samples, occuring from rarely to commonly. Whole and fragmentary quartz crystals are present in many of the residues; especially those from the Trempealeau formation. No attempt was made to obtain an accurate petrographic analysis of the sand.

SIGNIFICANT RELATIONS OF THE RESIDUES

In an insoluble residue analysis of rock samples there are two important angles from which to observe the relations of the analysis in respect to certain samples taken from definite units or members of certain formations: (1) The quantitative balance of soluble material, and insoluble material. (In this report the insoluble residue being divided into (a) silt and clay, (b) sand; (2) the microscopic character of the sand.

In this summary the different formations and members will be discussed separately as to the relations of the residues. Finally a brief summary as to the intermember and interformational relations of the residues will be discussed.

The Franconia Formation

Location 36, 40, and 41 in Pepin County and Locations 72 and 79 in Buffalo County all show, in their exposures, beds of the same horizon near the base of the Franconia formation. A key bed to this horizon, exposed at Locations 36, 41, and 72, is the highly crystallized sandy glauconitic limestone or dolomite tested in Sample 9, Location 36; sample 26, Location 41, and Sample 50, Location 72. The soluble content of this bed ranges from 58.5% to 79.5%, the clay and silt content is less than 8%, the sand content ranges from 20% to 41%. The microscopic character of the sand in the samples is 50% glauconite, which has altered in Samples 26 and 29 into a gray-white

color giving the grains the appearance of silicious oolites. The other 50% of the residue is frosted sand (probably quartz). No mica flakes or quartz crystals present.

Above the key bed are from 8½' to 17½' of argillaceous, thin-bedded, glauconitic sandstone varying somewhat in physical appearance but being very similar in the relation of the residues obtained from samples of this unit. None of the samples have over 18% soluble content most of them being much less, silt and clay content range from 6% at the base to between 20% and 30% at the top. Sand constitutes the bulk of all the samples tested save the key bed below. The microscopic character of the sand varies very little. Usually it is very fine to fine, angular to sub-angular and frosted (probably quartz) containing rare to common grains of glauconite, occasional mica flakes and very few quartz crystals. (The quartz crystals appear only in Samples 24 and 28.)

Locations 67, 68, and 76 all have a common base of approximately 65' above the base of the Franconia formation. The argillaceous mottled gray and buff sandstone units in the exposures at these locations all have the same physical appearance. The samples taken from the afore mentioned locations all have a low soluble content, 3% to 10% except in the units tested by samples 45, 63, and 76 which range from 17.3% to 47 + %. The general rule is a low soluble content, a high sand content, 65% to 95%, and a silt and clay content ranging from 14% to 24%. The microscopic character of the sand is like that of Locations 30, 40, 41, 72, and 79 except that the glauconite content is higher.

The Questionable Member

The Questionable member, between the Franconia formation and the St. Lawrence member of the Trempealeau formation, ranges from 6' to 14½' thick.

The key horizon to this member is a 2' to 4' unit of green sand conglomerate at the base of the member. Samples 36 and 37, Location 66, Buffalo County were tested from this key horizon. The results of the test will be found on Plate IX. The Questionable member was sampled at Location 37, Pepin County and Locations 64, 66, 84, 86, and 90 Buffalo County.

The samples taken from these locations show in their insoluble residue analyses that most of the beds are dolomitised sandstone or dolomitised silt stone with a few beds of sandy, silty dolomites with soluble content ranging from 5.9% to 51.1%, silt and clay content ranging from 7.6% to 50.7%, and sand content ranging from 10.9% to 80.5%.

In the microscopic character of the sand (except in samples 37, 38, and 39, taken from the basal 6' of the member at location 66,) is extremely fine to fine angular and clear (probably quartz). Grains show practically no frosting, quartz crystals are occasional; transparent mica flakes occasional to common; glauconite is usually fine grained, light green, blue green, and rare.

The St. Lawrence Member

The St. Lawrence member of the Trempealeau formation is 2' to 6' thick in the area. Samples were taken from this member at Location 37, Pepin County, and Locations 64, 66, 74, 84, 86, and 90 Buffalo County.

The insoluble residue analysis of the samples taken from these locations show the following balance of material:

Soluble content	-	47.7%	to 77.4%.
Silt and Clay content		8.6%	to 23.5%.
Sand content	-	9.1%	to 48.4%.

As this member is a sandy dolomite the soluble content is greatest; the sand content usually bulks larger than the silt and clay content.

The sand residue from samples of this member is usually quite similar in microscopic character. The sand is very fine to fine, angular to rounded, clear to frosted, probably quartz, containing quartz crystals up to 10% of the sand content of the sample, occasional transparent mica flakes, and glauconite ranging from rare grains up to 5% of the sand.

Lodi Member

The Lodi member is from 11' to 26' thick in the area, composed mainly of silty dolomites and dolomitic siltstones which are much alike in physical characteristics. Samples were taken from this member at Locations 37 and 42, Pepin County, and Location 74, 84, 86, and 90, Buffalo County. The balance of materials in the insoluble residue analysis of these samples is:

Soluble content	31.20%	to 66.5%
Silt, Clay content	8.63%	to 54.2% (Usually above 20%)
Sand content	.3%	to 56.40% (Usually much lower than the upper limit)

This member is surprisingly high in soluble carbonite content and low in sand content.

The microscopic character of the sand from samples taken from this member is very similar; usually an extremely fine to fine, angular to subangular clear sand (probably quartz) containing either occasional quartz crystals or none at all, rare to common appearance of mica flakes and usually less than 2% glauconite in small dark green grains. Samples 18, 20, 69, and 72 are all chert sand and their seems to be a coincidence in that samples 20, 69, and 72 all are from 8' to 10' above the base of the member.

Intermember and Interformational Relations and Differences of the Sand Residue

In the Franconia formation the two different series of beds studied, one series 10' to 27' above the base of the formation, the other series with its base 65' above the base of the formation, show the same general character

as to balance of soluble and insoluble material, and microscopic character of the sand residue. (See pages , 39, and 40.)

These series of beds differ from the questionable member and the members of the Trempealeau formation above in having a much lower soluble content, a lower silt and clay content, and a much higher sand content. The main difference in the microscopic character of the sand residue is a higher glauconite content, a relative absence of quartz crystals and a more rounded, frosted and slightly coarser sand.

The Questionable member differs from the St. Lawrence and Lodi members above in having a lower average soluble content, and a greater bulk of sand. This member usually has a higher clay and silt content than the St. Lawrence member and a lower clay and silt content than the Lodi member.

The main difference in the microscopic character of the sand in the Questionable member in respect to that in the St. Lawrence member above is less frosting of grains, a general smaller percentage of glauconite, and a finer and more angular sand in general.

The St. Lawrence member differs from the overlying Lodi member in having a very much smaller quantity of silt and clay, and a more uniform and greater bulk of sand. The microscopic character of the sand residue differs in being somewhat coarser, more rounded, more apt to be frosted, and having a higher glauconite content.

The Lodi member has definite characters of its own which have been brought forth in the preceding pages.

General Economic Aspects

One of the primary purposes of this report is to set forth the general criteria for determining the factors (from the stand point of the insoluble residue analyses) which make certain members of the Franconia and Trempealeau

formations better suited as sources of road surfacing material than others. The greatest single factor is the balance between soluble material, silt and clay, and sand.

In the Franconia formation the best rock for road surfacing is found (in the area investigated) in two series of beds, the base of one series of beds being 10' to 27' above the base of the formation, the base of the other series of beds, being about 65' above the base of the formation. Material used from these two series of argillaceous sandstones has proven satisfactory for use on light traffic roads. The average of service is usually from 3-5 years. (By light traffic roads in this area, town and county highways are meant, state trunk highways are classed under medium traffic roads.)

The balance of soluble material and silt and clay in respect to the sand content seems to be the determining factor in the case of road surfacing materials obtained from the Franconia formation. The locations of material in the Franconia sandstone which have the best service records are: Locations 68, 72, and 76.

The balance of materials at these locations is as follows:

Location 68

Average Soluble content	5.6%.		
" silt, clay "	18.8%		
Total Average of 2 types		24.4%	= 5/15
Average Sand content		75.6%	

Location 72

Average soluble content	5.3%		
Av. Silt, Clay "	23.5%		
Total Av. of 2 types		28.8%	= 6/14
Average Sand content		71.2	

Location 76

Average Soluble content	10.5		
Av. Silt, Clay content	20.6		
Total Av. of 2 types		31.1	= 6/14
Av. Sand content		68.9	

The above records show that the most serviceable material from the Franconia formation has a large bulk of sand but enough silt and clay and soluble material to produce sufficient binder to make a good surfacing for light traffic roads. Under medium or heavy traffic this material would not stand up because of the rapid breaking down of material due to the high percentage of sand present. Apparently on light traffic roads this sand forms a grit which makes a non slippery road in wet weather.

The Questionable Member

The Locations exposing this member, the material from which has the best service records, are Locations 64, 66, and 84. The balance of soluble material, silt and clay, and sand at these locations is as follows:

Location 64

Average soluble material content	38.4% - 8
Average silt and clay content	50.7% - 10
Average sand content	10.9% - 2

Location 66

Average soluble content	52.3% - 10
Average silt and clay content	20.6% - 4
Average sand content	27.1% - 6

Location 84

Avera ge soluble content	34.4% - 7
Average silt and clay content	37.3% - 7
Average sand content	28.3% - 6

In this member a little different condition exists than in the Franconia formation. The difficulty of working this member down into road surfacing by hand has prevented the same extensive use as road surfacing as the Franconia formation. When put on the roads in 4" slabs, the material wears much better than the Franconia but the break down of the rock to furnish binder is slow, making a rather rough surface. The determining factor in this member appears to be rock bulk. The high soluble content must combine with the silt and clay causing a relatively slow wear and consequently a slow release of binder.

While this material has proven satisfactory on medium traffic highways, and is more serviceable than the Franconia material, a material with a more rapid release of binder is considered better.

The St. Lawrence Member

In this area, the St. Lawrence member is so thin that it need be considered only as a member to be worked in conjunction with either the Questionable member below or the Lodi member above. The member is a sandy dolomite and will serve mainly to add rock bulk for wearing qualities to either member it is used with.

The Lodi Member

This member enjoys a rather unique position among the members studied in this report. Apparently the best source of road surfacing, it has been used the least. It is only recently that any attempt has been made to exploit this member as a source of road material, consequently the records of service are few. Where material from the member has been used for surfacing it has stood up well, presenting a smooth all weather surface with enough rock bulk to wear well and yet a rapid enough release of binder to permit a well bound, smooth, gradable surface to develop. The soluble material content is high, usually over 45%, clay and silt content is usually above 25%, and the sand content is usually below 20%. This member will probably furnish the best surfacing material of any of the members studied in connection with this report especially for medium traffic roads.

In conclusion, it is possible to rate the different members of the Franconia and Trempealeau formations as follows:

Sources of Surfacing Material

I. For Medium traffic roads.

1. Lodi Member

(a) Sufficient rock bulk for wearing qualities.

(b) Quick release of binder.

(c) High soluble content (usually over 45%), silt and clay content (usually over 25%), low sand content, (usually below 20%.)

2. Questionable Member

(a) Good rock bulk.

(b) Slow release of binder.

(c) Approximately 34% soluble, 35% silt and clay, 51% sand.

3. St. Lawrence Member

(a) Used for rock bulk with either 1 or 2.

II. For Light Traffic Roads only.

1. Either series of the Franconia formation.

(a) Poor rock bulk.

(b) Quick release of binder.

(c) High sand content, rather low silt and clay and soluble content.

The Lodi Member of the Trempealeau Formation as a Source of Agricultural Lime

The results of the insoluble residue analysis of samples from the Lodi member of the Trempealeau formation open, for exploitation, an as yet untouched source of agricultural lime. The Lodi member, in the area from which the

samples were collected, has an unexpectedly high calcareous content which generally exceeds 50% of the rock, by weight. The calcareous content is in the form of $CaCO_3$ and $MgCo_3$; the bulk of insoluble material is silt and clay; the sand content is very low.

The Lodi member is mainly composed of thin beds of finely and evenly textured, silty dolomite. The rock can be easily removed and crushed for agricultural lime. Locally it can be produced as ground lime much more cheaply than the more commonly known formations producing agricultural lime.

The ground lime obtained from the Lodi member will be especially suited for use on sandy soil as the insoluble silt and clay will increase the physical fitness of the soil for cropping, at the same time the calcareous content is being released from the lime.

There are large areas in central western Wisconsin where local exploitation of the better known formations producing agricultural lime is not economically feasible. In other areas these formations are absent. The areas affected by the lack of agricultural lime have, in many cases, ready access to workable exposures of the Lodi member of the Trempealeau formation. Careful consideration should be given the Lodi member in these areas.

In the writer's fields experience, the area where material similar to that studied in connection with this report occurs includes: Crawford, Vernon, LaCrosse, Trempealeau, Buffalo, Pepin, and Eau Claire Counties.