# RAPID FIELD METHOD FOR DETERMINING THE POLISH SUSCEPTIBILITY OF CARBONATE AGGREGATES

by

Tom S. Patty
Geologist II

Materials and Tests Division
Texas Highway Department

3-20-71-022(4)
August 1974

# PREFACE

Along with the increase in traffic volume and speed on the public highways, there has been an increasing need for safety awareness. For years now, many state and federal agencies have been developing and applying techniques and devices to assist in monitoring or evaluating pavement surfaces for polishing character or skid properties. Many have gathered convincing evidence to support theories as to the relationships between aggregate composition, pavement-surface texture and desired skid resistance. Most of these methods have provided information in hindsight or after a pavement has been in service; whereas, only a few have been developed to evaluate an aggregate before it is used. And of these few techniques, each generally requires fairly elaborate equipment and are often time consuming. The proposed method described herein can provide a means by which a technician with only limited equipment and time can make a rapid evaluation of a limestone aggregate in terms of its relative susceptibility to polishing under traffic.

ABSTRACT

A quick and simple method by which limestones and related carbonate paving aggregates can be rated as to their relative susceptibility to polishing has been successfully applied to a wide number of aggregate sources used on Texas Highway projects. The technique involves taking a small representative sample of the aggregate and subjecting it to a dilute hydrochloric acid treatment for about 20 seconds. The etched particles are washed, examined under a 10-15X handlens or a stereoscopic microscope, and the resulting surface texture is then compared to a set of photos or diagrams for rating. The rating system, developed from the examination of over a hundred carbonate sources, can assist in judging a material's potential susceptibility and resistance to polishing. Data from laboratory and field-trial studies when compared to duplicate samples tested by the Accelerated Polishing Test (Test Method Tex 438-A), shows that a Textural Rating of 1 correlates to a range of measured polish values of 25 to 33, a rating of 2 correlates to polish values in the range of 34 to 37 and a rating of 3 correlates to polish values greater than 37.

CONTENTS

I. SUBJECT

Often Departmental personnel desire limited but basic information about several potential material sources in their area prior to initiating paving projects. In addition, because of limited funds, it would be desirable to utilize local laboratory facilities and personnel in conducting the preliminary evaluation of a material source. The subject of this study is the presentation of a simple and rapid method, capable of being used by field personnel, by which carbonate aggregates can be evaluated in terms of their relative susceptibility to polishing.

II. PURPOSE

The purpose of this report is to make available to Departmental personnel a quick and simple method of rating the relative susceptibility of paving aggregate to polishing.

III. SUMMARY AND CONCLUSIONS

1. A quick, simple and inexpensive technique, which involves the acid treatment of carbonate aggregates and evaluating their surface microtexture, provides an effective means of rating certain paving materials as to their relative susceptibility to polishing.

2. Materials from forty sources including both commercial and noncommercial operations in Texas and southern Oklahoma have been treated using the proposed "Rapid Field Method." Their respective microtextures have been rated and are found to correlate closely with the results of the Accelerated Polish Test.

3. The data shows that aggregates with a Textural Rating of 1 are composed primarily of high purity limestones and dolomites and have polish values ranging from 25 to 33. Aggregates with a Textural Rating of 2 include impure limestones with marginal polish values in the range of 34 to 37 and those with a rating of 3 include sandy limestones, caliches and calcareous sandstones which have polish values in excess of 37.

## IV. MATERIALS AND METHODS

A. Samples. A total of forty carbonate-aggregate sources representing a wide variety of geological rock units and deposits throughout Texas and southern Oklahoma were subjected to the proposed subject treatment and their textural features compared. These selected sources listed in Table I represent crushed limestone and dolomite quarry sites from the major commercial producers and some non-commercial sites. They also include limestone river-gravel pits. Two are calcareous quartzose sandstone quarries and one is a roadside outcrop. One oyster-shell sample was selected to represent the Gulf Coastal oyster and clam-shell aggregate types.

The location of the forty sources used in this study are indicated on a County Outline Map illustrated as Figure 19. As shown on the map, six of the selected sources are situated in southern Oklahoma.

Most of the aggregates collected and examined for this study were taken from samples submitted for highway projects, however, a few were taken from the sources for informational purposes.

All samples were handled and tested in the laboratory according to Test Method Tex 438-A.

B. Apparatus. The equipment used in developing the method described herein is relatively inexpensive and can easily be obtained by field personnel. The containers used for carrying and dispensing water and dilute hydrochloric acid may either be glass or polyethylene. In addition, the beakers for acid etching and rinsing may also be glass or plastic (Fig. 1). Either a 600 ml or 400 ml size beaker (Griffin, low form type) will be satisfactory. For the examination of the particle surface texture after the acid treatment a 10X or 12X handlens is recommended (Fig. 2). The 10% hydrochloric acid solution can be mixed and stored in the lab and carried to the quarry site or stockpile in convenient containers. The water used can be tap water and may be carried in a similar manner.

C. Procedure. The outline presented below has undergone both field and laboratory trial testing by personnel of the Materials and Tests Division and is used as a "quickie" test on all carbonate samples submitted for the Accelerated Polish Test (Tex 438-A).

Step 1. Place about a 50 g sample of the aggregate to be evaluated in a 600 ml beaker, slowly add 150 ml of 10% hydrochloric acid and gently swirl for 20 seconds.

Note:

A 50 g sample is approximately 25-30 particles of 1/2"-3/8" size

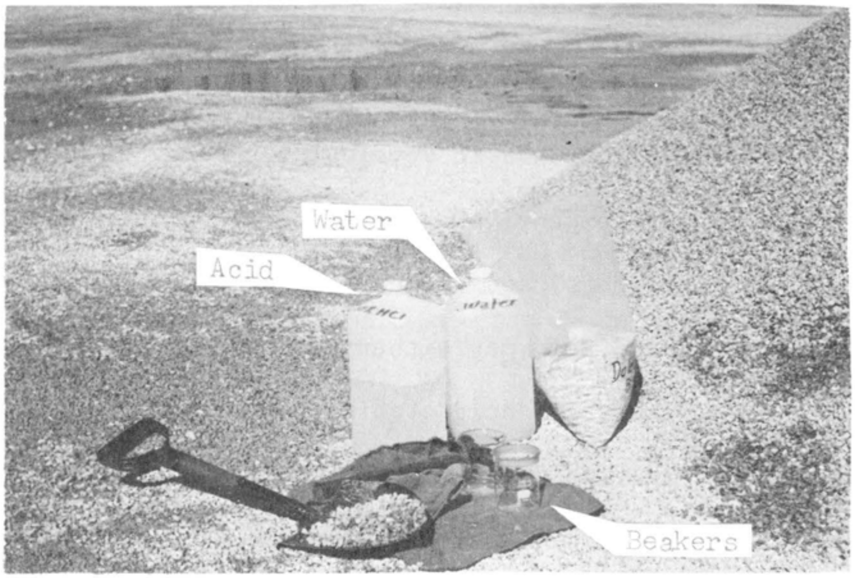



Fig. 1. Equipment used in the field for acid treating and rinsing aggregate samples.


Fig. 2. An inexpensive 10 or 12 power handlens is adequate to observe the particle surface texture after the acid treatment. The aggregate particle is also hand held at the plane of focus, about 1" from the handlens.

material but may vary somewhat due to different specific gravities. This amount is also approximately a small handful. The sample can be taken from production stockpiles or from the quarry face. The rock may also be added to the beaker after the acid solution has been measured out. The 150 ml is also an arbitrary amount and subject to experience of the operator. As the acid solution comes into contact with carbonate aggregates, carbon dioxide gas is given off causing the solution to bubble and foam. The intensity of the bubbling or effervescence is often an indication of the relative purity of the limestone. Dolomite will hardly bubble at all unless scratched or heated. Heating the solution in some manner may be required to get an adequate reaction. In addition, the reaction will usually separate some of the included impurities from the aggregate particles. Carbonaceous materials generally float on the foam and heavier insoluble sand grains sink. See Figures 3 and 4.

Step 2. At the end of the 20 second acid treatment, add sufficient amount of water to fill beaker, decant and repeat water rinsing and decantation twice more.

Note:

The 20 second acid-treatment time is arbitrary and subject to the experience of the operator. A shorter or longer treatment period may be successfully used depending on the purity of the limestone. Rinsing and decantation should be repeated until all reaction has stopped but normally a couple of times is adequate. See Figures 5 and 6.


Fig. 3. Removing about 50 g of representative aggregate for placement in beaker and acid treatment.

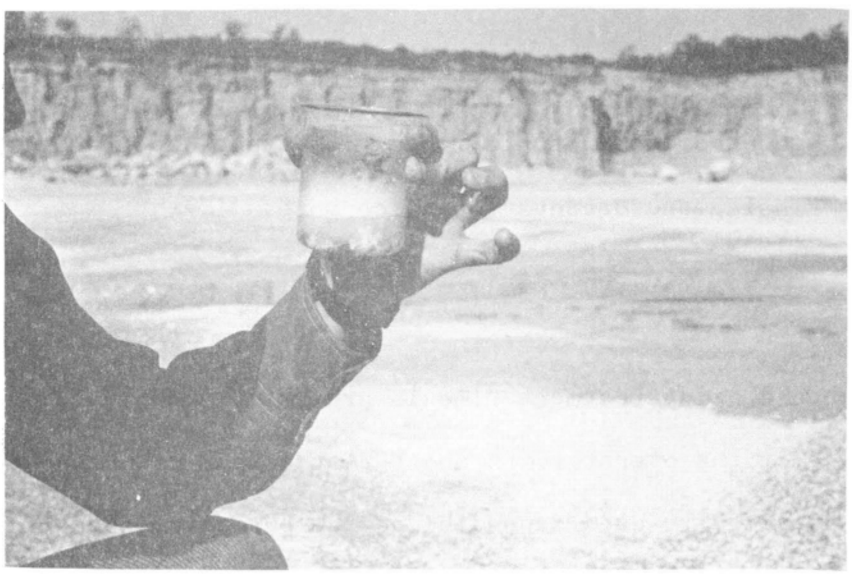


Fig. 4. Reaction of a limestone aggregate to the hydrochloric acid treatment. Note darker organic residue floating to the top of the foam.

Step 3. Remove treated and rinsed aggregate particles from beaker and place them on cloth or paper toweling to absorb excess surface water (see Fig. 7).

Note:

Simply pour out the aggregate particles onto a clean cloth towel or 3-4 sheets of paper toweling and gently rub or pat the particles until surface-dried condition is reached.

Step 4. Examine each of the particles with a handlens for surface-texture character and compare with the photographs and diagrams presented as Figures 10-18 to establish an average rating number based on a scale from 1 to 3. A rating of 1 indicates the absence of surface microtexture, 2 intermediate and a rating of 3 indicates material with pronounced microtexture.

Note:

An operator may quickly scan a dozen or so particles placed in the palm with a handlens or examine individual particles by grasping them between thumb and index finger. The specimens should be brought into the plane of focus (about 1" from lens) and slowly rotated in order that all sides can be examined (see Figures 8 and 9).

## V. RESULTS

Materials were collected from forty aggregate sources in Texas and southern Oklahoma and tested with the procedure outlined herein. A list of these sources is given in Table I and the general locations are plotted on the County Outline Map illustrated as Figure 19. All sites represent commercial or contractors pits which have been used or

Fig. 5. Flushing and rinsing the acid-treated aggregate sample with water.

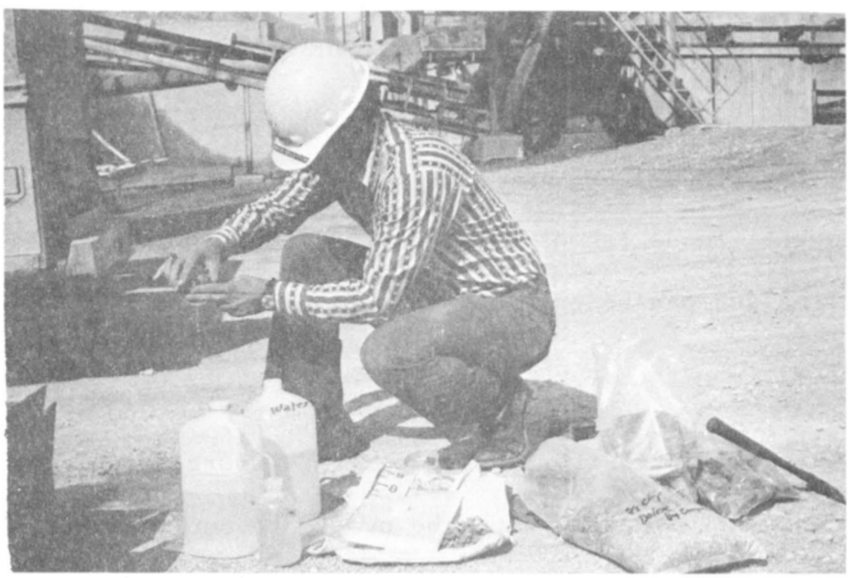


Fig. 6. Rinsing and decanting the acid-treated sample.

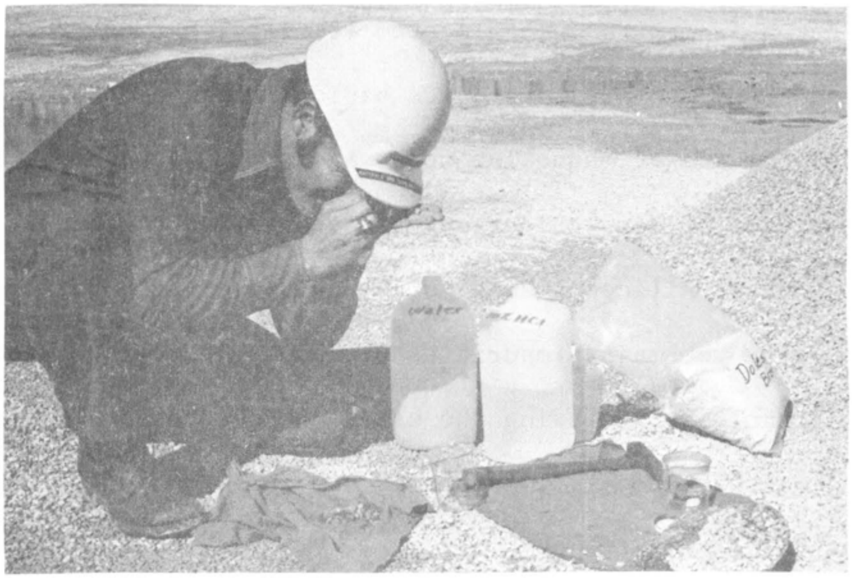
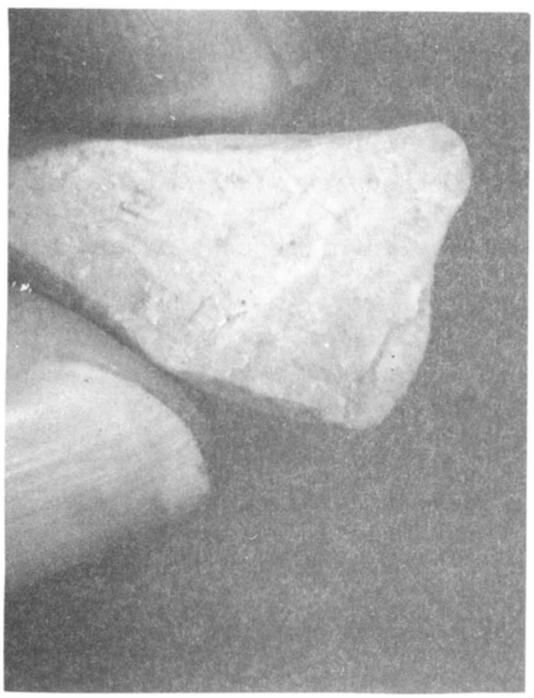
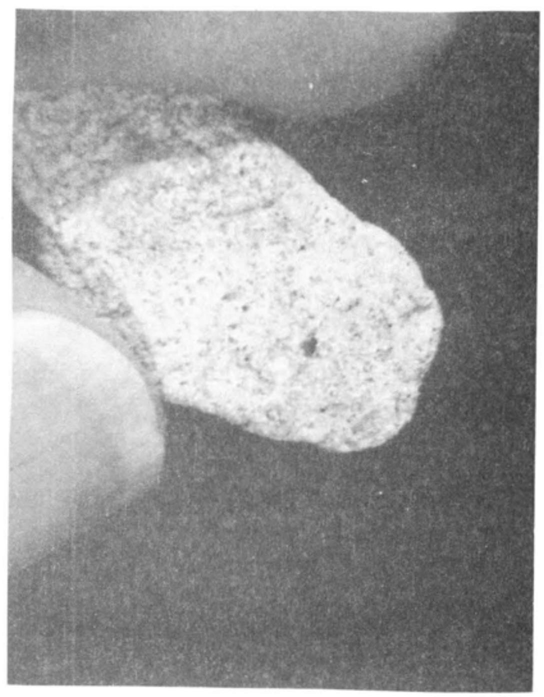


Fig. 7. The acid-treated and rinsed sample is placed on a dry towel to remove excess surface water. The particles are each examined with a handlens for surface-textural characteristics.





Figs. 8 and 9. View of two carbonate aggregate particles which have been acid treated for 20 seconds. Sample on left is a relatively high-purity limestone which exhibits a very smooth surface texture, whereas, the particle on the right is an impure, sandy limestone showing a high degree of surface texture.

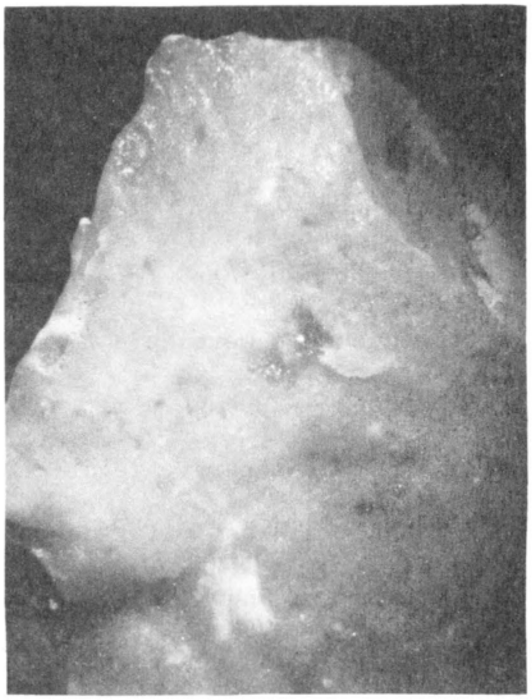
proposed for use on State Highway projects with the exception of one which was taken from a road cut located 15 miles west of Sterling City. Each represent sedimentary rock units basically composed of a carbonate mineral (calcium and/or magnesium carbonate) or a carbonate cementing agent in the case of some calcareous sandstones and caliches. Other components such as siliceous sand, clay, carbonaceous material and fossils comprise the major impurities or insoluble residues noted. Petrographic analyses including the use of thin-sections were utilized in identifying the type of limestone or carbonate aggregate examined for this study.

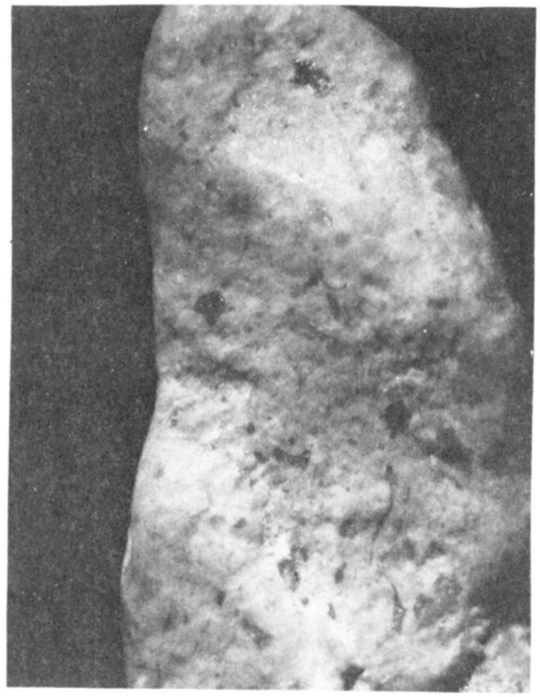
When collected, each of the forty aggregates was subjected to the "Quickie Test" by three laboratory personnel and each sample was given a Texture Rating or 1, 2 or 3 as indicated in Table I. Nine of the commercial sources were actually tested at the quarry sites by the writer using the portable equipment illustrated in Figures 3-7. After establishing and agreeing on a Texture Rating for each sample, the material was tested in accordance to Test Method Tex 438-A "Accelerated Polish Test For Coarse Aggregate." This test involves casting at least 7 specimens which are subjected to nine hours of polishing with the British Accelerated Polishing Machine and measured for frictional properties with the British Portable Tester (BPT). The results of the Accelerated Polish Test for each of the sources are also listed in Table I. Over half of the listed sources are from commercial quarries which have supplied materials to State Highway projects to the extent that a fairly good history of polish tests have been accumulated. The polish value listed for those sources represent an average of test results from several samples.

In establishing a diagrammatic and pictorial scheme which would allow a technician to comparatively rate the acid-etched surface of aggregate particles, a number of samples from limestone sources were acid treated and their respective textured surfaces photographed through a microscope. To show that variations exist within the arbitrary categories, two photos were taken of different sources that exhibit similar degrees of surface texture after etching. Figures 10 and 11 show the smooth surfaces of high purity limestones. These samples also represent materials with insoluble residues of less than 2-3% and are considered to have a Textural Rating of 1. A diagrammatic representation of this type of microtexture is illustrated in Figure 12. Polish values which correspond to a Textural Rating of 1 range from 25 to 33 (see Table I).

Figures 13 and 14 are photos of aggregates with intermediate surface microtexture. The insoluble residues range from about 5-15% and the particles are classified as having a Textural Rating of 2. Figure 15 is a diagram of a particle showing a similar texture. Polish values which correspond to this type of intermediate microtexture range from about 34 to 37.

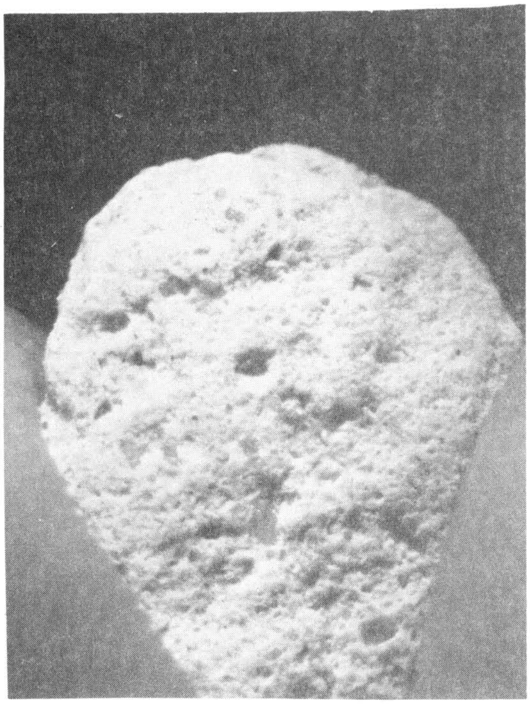
Figures 16 and 17 illustrate sandy limestones or sandy caliches with insoluble residues ranging in excess of 25%. The surface microtexture after the acid treatment feels like sandpaper to the touch and appears

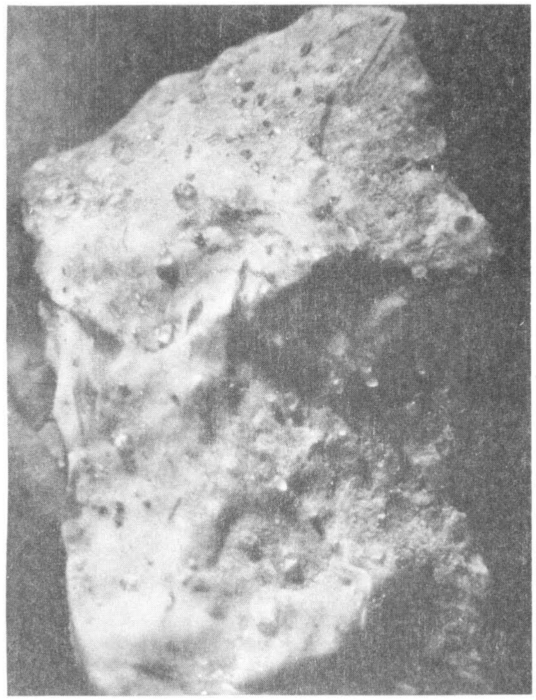




Figs. 10 and 11. Photomicrographs of relatively high purity limestones showing smooth surfaces after being subjected to a 20 second acid treatment. Carbonate aggregates which exhibit surfaces with this type of smooth unbroken surface are given a <u>Textural Rating of 1</u>.

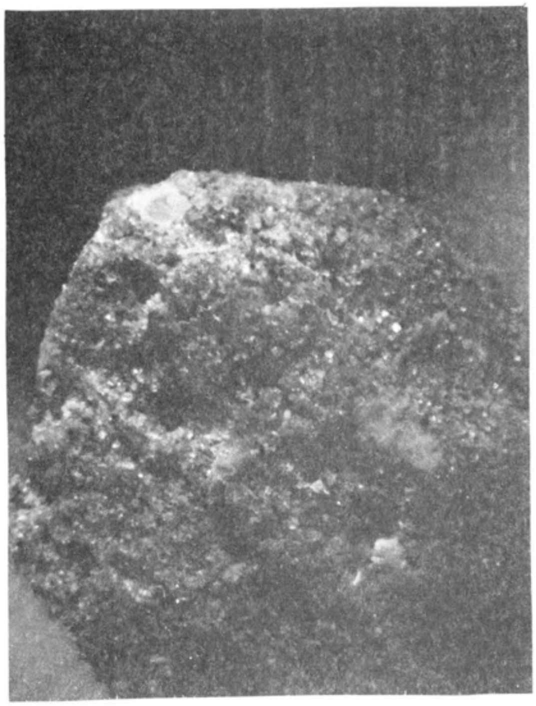
Fig. 12. Diagrammatic representation of a particle with a <u>Textural Rating of 1</u>.

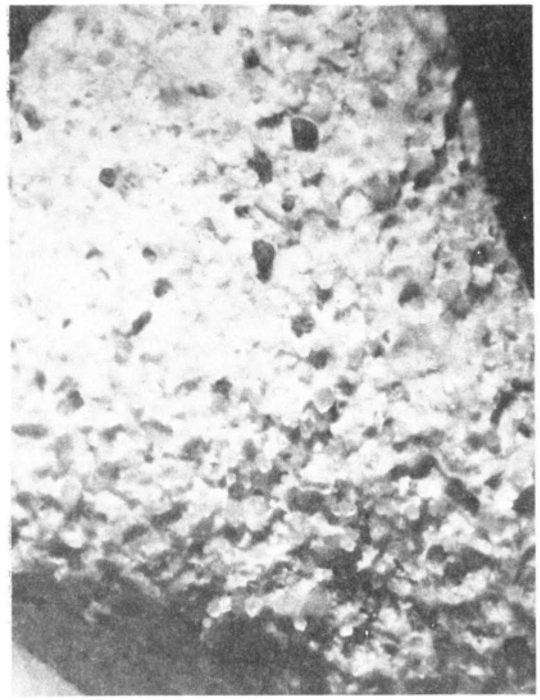




Figs. 13 and 14. Photomicrographs of sandy caliche (left) and sandy limestone with intermediate textural properties. The insoluble residue ranges from 5-15%. These particles represent a Textural Rating of 2.

Fig. 15. Diagrammatic representation of a particle with a Textural Rating of 2.





Figs. 16 and 17. Photomicrographs of sandy limestone particles exhibiting a Textural Rating of 3. Aggregate particles with high sand contents have a "sandpaper" feeling after the 20 second acid treatment. The insoluble residue content of these samples range up to 30-40%.

Fig. 18. Diagrammatic representation of a particle with a Textural Rating of 3.

very sandy under a handlens. Figure 18 is a diagram showing a highly textured surface classified as having a Textural Rating of 3. Often carbonate aggregates with a high "gritty" texture have correspondingly high loss by the Los Angeles Abrasion Test.

A general composition for the forty sources used in this study is also given in Table I.

## VI. DISCUSSION

For some time now it has been observed that certain relationships exist between an aggregate's basic petrographic characteristics, such as mineral composition, grain size and texture and its measured polish value as determined by the British Portable Tester. However, these observations have been limited to the research laboratory and have had no direct application for use in the field and in general, have had to be performed by a specialist. A number of laboratory techniques, in addition to the Accelerated Polish Test, have been explored in an attempt to predetermine an aggregate's susceptibility to polishing. But in the case of the Polish Test, elaborate equipment, a trained technician (or specialist) and often several days are required to get results back to the field. With regard to both time and economics a simple, quick and effective method of establishing an aggregate's microtexture (a clue to its susceptibility to polishing) has been developed. The limited number of field trials have been successful both in predicting the relative polish values of proposed aggregates and establishing the feasibility of the procedure under field conditions with portable equipment.

Table I

Microtexture Rating of Carbonate Aggregates And Corresponding Polish Values

| Source No. | Composition | Microtexture Rating | Polish Value |
|---|---|---|---|
| 5 | High Purity Limestone | 1 | 27 |
| 6 | High Purity Limestone | 1 | 29 |
| 7 | High Purity Limestone | 1 | 27 |
| 8 | High Purity Limestone | 1 | 25 |
| 10 | Limestone Gravel | 1 | 31 |
| 18 | High Purity Dolomite | 1 | 28 |
| 19 | Oyster Shell | 1 | 32 |
| 20 | High Purity Limestone | 1 | 29 |
| 21 | High Purity Limestone | 1 | 33 |
| 22 | High Purity Limestone | 1 | 31 |
| 23 | Limestone Gravel | 1 | 29 |
| 26 | Limestone Gravel | 1 | 29 |
| 27 | High Purity Limestone | 1 | 31 |
| 31 | Dolomitic Limestone | 1 | 30 |
| 33 | Limestone Gravel | 1 | 30 |
| 36 | Cherty Limestone | 1 | 33 |
| 37 | Dolomitic Limestone | 1 | 33 |
| 38 | Dolomitic Limestone | 1 | 30 |
| 39 | Dolomitic Limestone | 1 | 28 |
| 40 | Dolomitic Limestone | 1 | 32 |

Table I - Continued

| Source No. | Composition | Microtexture Rating | Polish Value |
|---|---|---|---|
| 1 | Sandy Limestone | 2 | 37 |
| 2 | Sandy Limestone | 2 | 35 |
| 9 | Shaley Limestone | 2 | 34 |
| 11 | Reef Limestone | 2 | 35 |
| 16 | Limestone Gravel | 2 | 34 |
| 17 | "Honeycomb" Limestone-Dolomite | 2 | 34 |
| 28 | Sandy Limestone | 2 | 35 |
| 29 | Shaley, Sandy Limestone | 2 | 35 |
| 30 | Sandy Dolomite | 2 | 37 |
| 34 | Sandy Caliche | 2 | 37 |
| 35 | Shaley, Cherty Dolomite | 2 | 35 |
| | | | |
| 3 | Sandy Limestone | 3 | 40 |
| 4 | Sandy, Reef Limestone | 3 | 40 |
| 12 | Sandy Limestone | 3 | 42 |
| 13 | Sandy Limestone | 3 | 40 |
| 14 | Calcareous Sandstone | 3 | 41 |
| 15 | Sandy Limestone | 3 | 41 |
| 24 | Caliche Sandstone | 3 | 42 |
| 25 | Limestone Rock Asphalt | 3 | 42 |
| 32 | Sandy Caliche | 3 | 42 |

Although restricted to a variety of carbonate aggregates, including limestones, dolomites, caliches and calcareous sandstones, the "Rapid Field Method" or "Quickie Test" can provide District personnel with a technique to evaluate, classify or rate on a 1-3 scale the carbonate paving aggregates proposed for use on highway projects which have a polish value requirement. This proposed field method is presented as a rapid "indicator" test for use in predicting polishing tendencies of carbonate materials and is not intended to take the place of the Accelerated Polish Test. Specifications on certain paving items require the coarse aggregate to meet a polish value of either 30, 33 or 35 when tested in accordance to Test Method Tex 438-A. The four-step proposed procedure described herein will enable District personnel to better evaluate untested limestone materials and decide whether or not it would be of any benefit to submit an official sample for the Accelerated Polish Test. Non-commercial pits could be examined and tested on the spot or evaluated in the District or Residency laboratories.

In summary, the four-step "Rapid Field Method" involves acid treating a small quantity of a carbonate aggregate, rinsing, examining with a handlens and making comparisons with illustrations for rating. It has been found that the textural-rating numbers correspond to polish-value ranges, thus, permitting a relatively quick and reliable evaluation by field personnel. However, other engineering properties of an aggregate such as Los Angeles Abrasion should be taken into account. It has often been found with certain limestone and caliches that as the sand-sized insolubles increase the more likely the material will have a higher loss to abrasion.

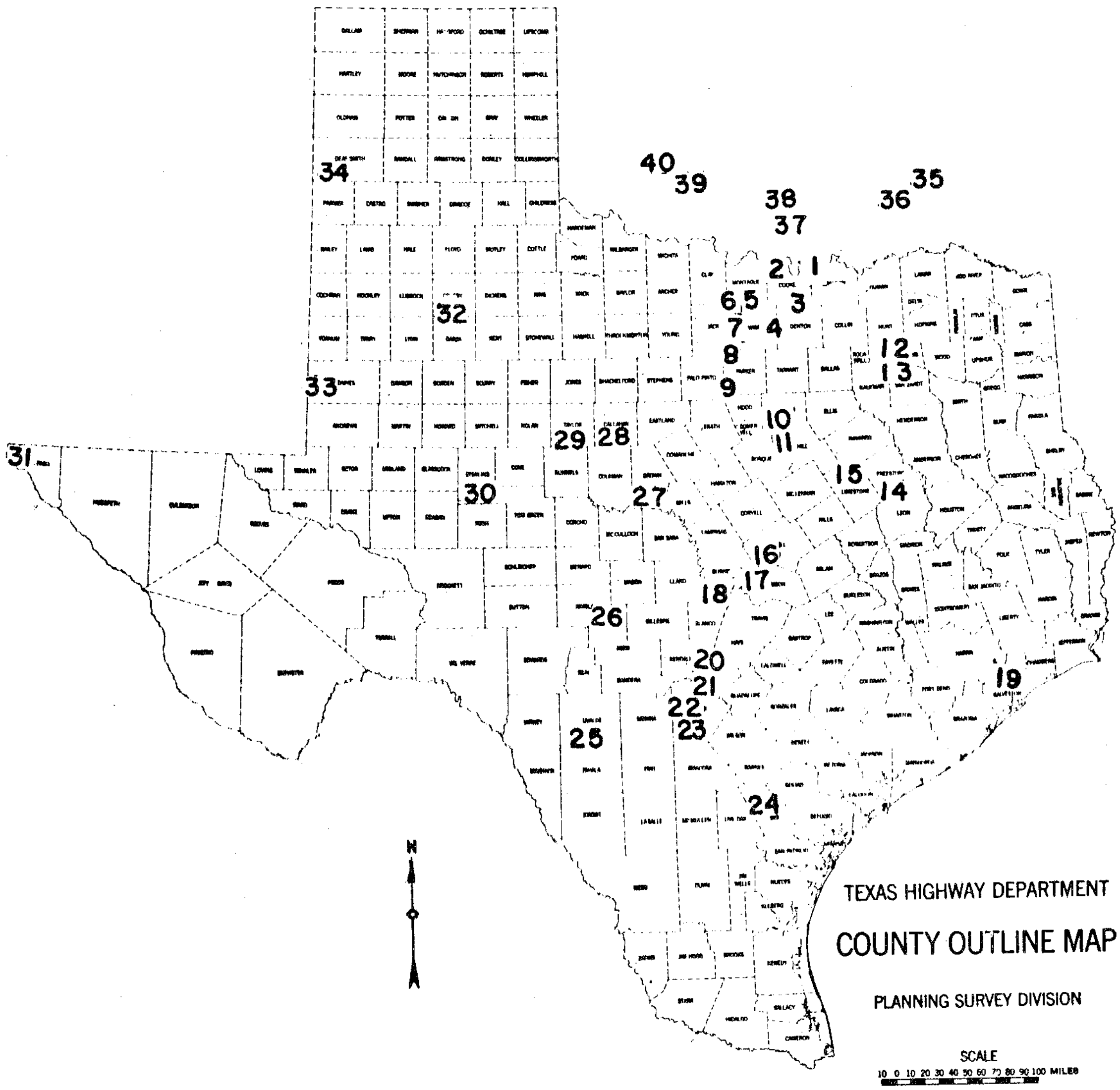



Fig. 19. Location map for the sources used in this study.