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THE GEOLOGIST'S ROLE IN HIGHWAY ENGINEERING

W. T. Parrott, Highway Geologist
Virginia Department of Highways

The role of the geologist in highway engineering is not new, but within the past 20 years the use of geology in the field of highway construction has been steadily increasing. As far back as 1898 the Maryland Highway Division was a part of the Maryland Geological Survey, but in 1910 the Maryland State Roads Commission incorporated the highway division into its organization. In 1955, Dr. J. T. Singewald, Jr., Director, Maryland Department of Geology, Mines and Water Resources, sent a questionnaire to the Association of American State Geologists, requesting information on the employment of geologists by their respective highway departments. The replies indicated that 23 highway departments employed from 1 to 10 geologists. This questionnaire also revealed that Ohio was the first State, 1914, to employ a geologist in its highway department, and that the first highway geological section was established in 1923 by Missouri. On January 1, 1947, the Virginia Department of Highways established a geological section within the Testing Division, with the writer as the highway geologist. Since then, the staff has been increased to eight geologists.

The duties of a highway geologist are numerous; however, an analysis of the work done by a highway geological section and that done by a geological survey shows that there is no duplication or competition. The function of a state highway department is to build and maintain highways and necessary structures. The construction materials are geologic in origin and the structures rest on geologic foundations. The more costly the road and the more exacting the traffic requirements, the more essential it is to use geologic knowledge in the design and construction of the highway.

The functions of a highway geologist are:

1. To locate stone quarries and sand and gravel pits
2. To conduct local or statewide surveys for aggregate
3. To supervise core drilling and interpret core drill data
4. To make geophysical surveys, either seismic or electrical resistivity
5. To make vibration studies in connection with potential blast damage
6. To investigate slides or areas of potential slides and suggest either preventive or remedial measures
7. To assist in design of slopes and benches
8. To investigate alleged blast damage to wells, springs and dwellings
9. To act as an expert witness in litigation
10. To instruct engineer trainees in refresher courses in general geology.

An examination of these primary functions will show what specific knowledge is required and that a specially trained geologist, preferably one with some engineering experience, is needed to appraise accurately the existing conditions. Such training is gained by experience or a course in engineering geology.

Plate 1. Core drilling for bridge foundation at Cedar Creek, Frederick-Shenandoah county line.

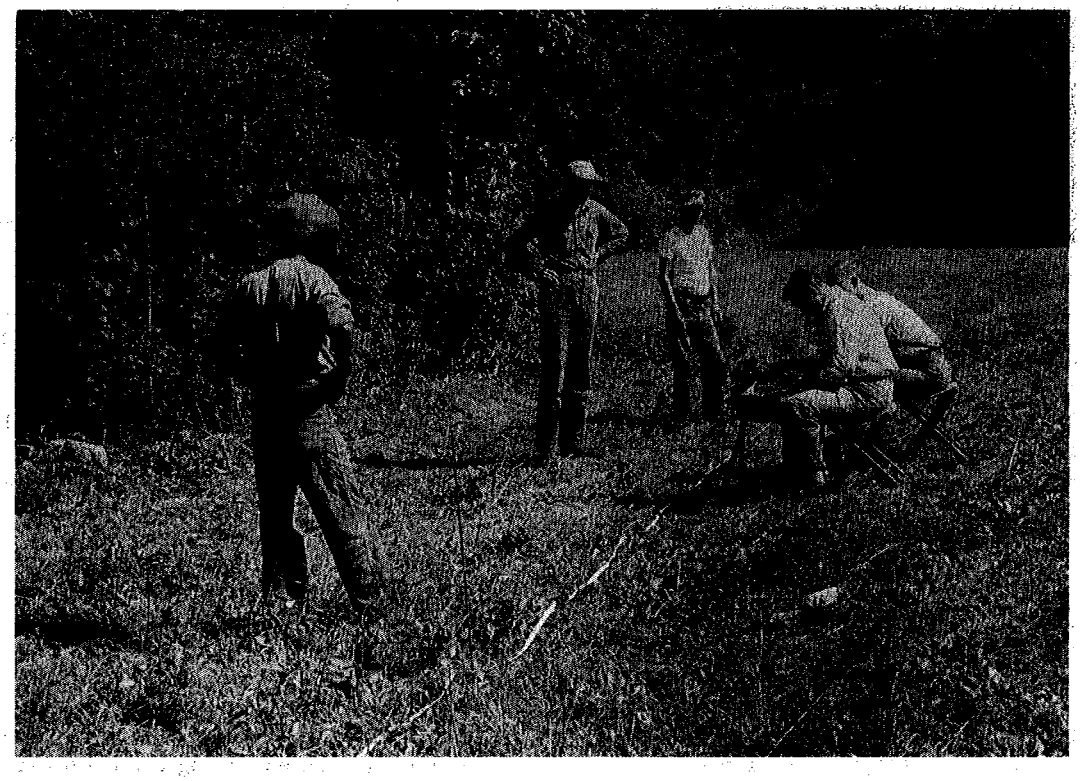

Plate 2. Resistivity unit in use to check depth of river gravel over bedrock in Alleghany County.

In the location of a quarry, the most important items are the quantity, quality, and availability of the stone. Generally, the most important physical properties of good highway aggregate are low abrasion loss, freedom from injurious minerals, and affinity for bituminous material. Depending on the purpose for which the stone is to be used, an abrasion loss up to 43% is acceptable for most primary construction and maintenance work. Almost all granite, granite gneiss, limestone, dolomite, basalt, and greenstone will meet these specifications. Aggregates that contain a high percentage of mica, chlorite, or talc will give a poor bond with bituminous material and their adhesive qualities in various bituminous mixes should be predetermined by laboratory tests.

In conducting an aggregate survey for either a specific project or on a statewide basis, a comprehensive knowledge of the previously mentioned physical properties of the stone is necessary so that the material selected will meet specifications. In this manner, the geologist assists the engineer in locating the materials that are available nearest the project, thus eliminating long hauls and reducing the cost of the project.

Superficial rod soundings for bridges have been replaced by detailed exploration by core drills, and probably one of the biggest jobs of the highway geologist is correlating and interpreting core drill data. In rock, the core drilling entails the cutting of a rock core, which is examined for fractures, mineral content, and degree of weathering. In unconsolidated material, samples of sand, clay, or gravel are taken and examined for moisture content and degree of plasticity, and the resistance the material offered to drill casing or sampling spoon is noted. Once these data are obtained, an accurate appraisal of the results by the geologist gives a picture of the subsurface conditions to the bridge designer and a bridge can be designed for the best, as well as the worst, conditions that may be encountered, with substantial savings in the design.

Geophysical advances that have aided the geologist and the engineer are electrical and seismic subsurface surveys. The old method of estimating the amount of rock and soil which may be encountered has given way to the more accurate determination by either resistivity or seismic methods. Both of these methods are used by state highway departments. The seismic method is a small scale utilization of the reflection principle which is used by oil companies in exploratory work. A small charge of dynamite is exploded, setting up seismic waves, which are recorded on special instruments placed at various distances from the shot point. The interval between time of shot and arrival of the seismic waves at recording stations is measured and the velocity of waves determined. Because various materials transmit the waves at different velocities, this information is used with the known geology of the region to interpret the subsurface conditions. The electrical resistivity method is probably more popular because it requires less equipment, eliminates the danger from explosives, and affords greater portability. This method measures the resistance that material will offer a given amount of electric current. By correlating this information with the known geology, aided by one or two test holes, a very accurate rock-soil profile can be developed. From cross sections drawn of the proposed construction, the highway designer can calculate the over-all amount of cut and fill he may have in a given area; however, with the rock-soil profile, it is possible to determine the amount of rock available for the base of the fill and the amount of material available for capping or for borrow purposes. The Virginia Department of Highways has been using the resistivity method since 1950, and predictions based on this rock-soil profile have averaged 98 percent correct as proved by actual construction.

One of the greatest bugbears with which a highway department may be faced is an enormous number of claims from property owners who live in areas adjacent to construction limits, that their wells, springs, or dwellings have been injured by blasting during construction. Vibration studies have come to the aid of the engineers in such cases. In the past, the determination of alleged damage has been based on personal observation and the reports of the people on the construction project and of the property owners. However, there was rarely concrete evidence, except in a few cases, that would support the contention of either side. Within the past few years the development of an instrument for the measurement of vibration and the acceleration of shock waves through the earth and rock has gone far to eliminate potential court cases, as well as to substantiate the claims of the state or property owner. In fact, the science of vibration study is rapidly developing a branch of specialists who can render great aid to any individual or corporation faced with potential blast damage. The use of these experts, plus their recording machine, has, in at least two cases, saved the state and the taxpayers thousands of dollars in refuting the claims of private individuals who claimed that their property had been damaged. With the expanding use of these instruments it is believed that virtually all claims will be placed on a scientific basis and each can be decided upon its own merits.

One of the natural phenomena that can be very time consuming to the highway geologist is landslides and rock falls. Contrary to popular opinion, a landslide need not be a catastrophic occurrence, but may take the form of relatively small amounts of rock and earth that plague the highway engineers in either old or new construction.

Plate 3. Slide on U. S. Highway 60, east of Covington, Alleghany County. This slide was caused by movement of supersaturated clay and sand, and it covered the 4-lane highway with 3 to 11 feet of debris.

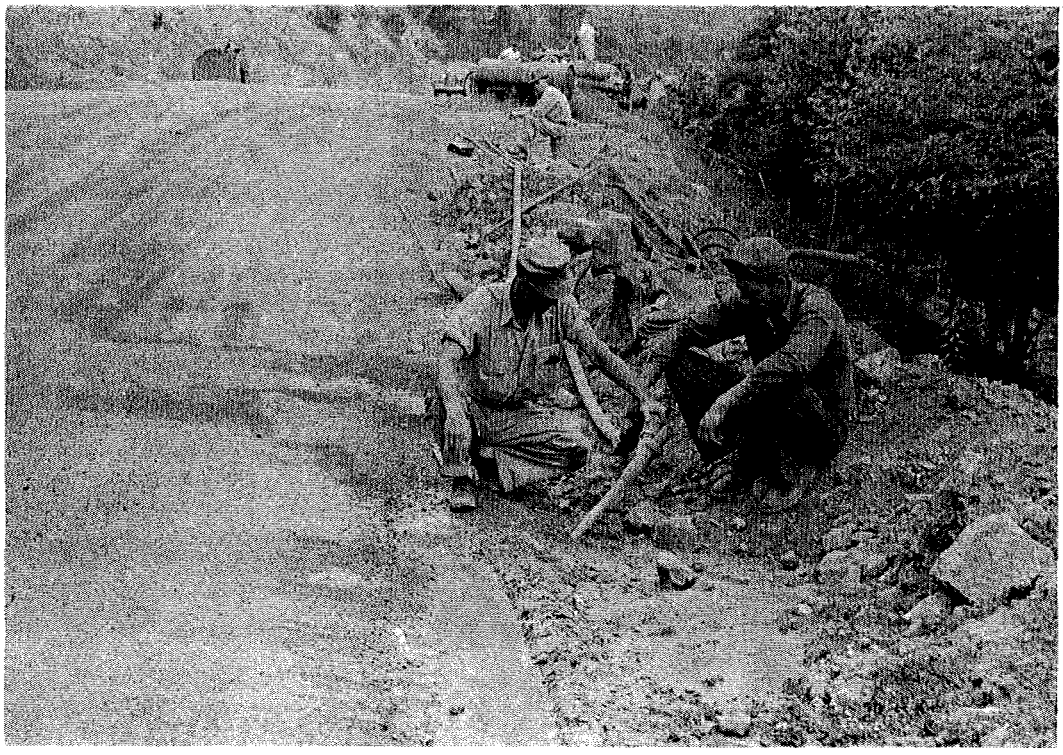

Plate 4. Grouting on U. S. Highway 460, two miles northeast of Narrows, Giles County. The mixture of water, sand, and cement is being pumped into a fill.

It is the duty of the highway geologist to inform the design engineer of any area that offers a slide potential and to suggest preventive measures which would eliminate or at least reduce the danger of slides. Once a slide has occurred, it is also the highway geologist's duty to suggest remedial measures which will prevent future slides. Some of these measures are benching, flattening the slope, stabilizing the area by vegetation, and last, but far from least, is proper drainage. In some instances vertical sand drains, which are drill holes filled with sand to remove excess moisture, are used. Grouting is also used; that is, a mixture of sand, water and cement is pumped into the ground and the mixture, or grout, forces out excessive moisture and occupies the former voids. Upon setting, the grout binds the soil together and prevents water from entering the area treated. In grouting an area, adequate provision must be made for escape of ground water; otherwise, the building of hydrostatic pressure may wreck all efforts to control the slide.

With the inauguration of the new federal highway program, the proper design of slopes and benches that will conform to the standards of the Federal specifications has increased the work of the highway geologist. Each of these cases is an individual one and the benching and sloping must be tailored to suit the existing conditions.

Another facet of the highway geologist's duties is that of acting as an expert witness in litigation between property owners or contractors and the state. Any of the aforementioned functions may be used as a basis of litigation, and the testimony of the geologist may lead to a favorable judicial decision. The two subjects on which the highway geologist is called upon to testify most frequently are damage to water supplies and dwellings.

A very important function of the highway geologist is to offer a short refresher course in general geology to engineer trainees. Most of these men have had at least one course in general geology while in college, but it is a duty of the geologist to point out the more special aspects of geology as applied to highway engineering. In this course the young engineer learns that geology is another tool with which the adverse conditions and agents of nature may be more successfully controlled. Within the past ten years, at least 100 or more engineer trainees have been given this refresher course.

This resume of the geologist's role in highway engineering presents a brief picture of his part in the world of highway construction. As the highway program progresses, it is becoming more and more apparent that the advice and studies of the geologist regarding highway problems are a great aid to the construction engineer. It is not claimed for one instance that geology in itself is a panacea for all highway problems, but if used intelligently it can go far in helping to eliminate some of the vexing problems with which the highway engineers are confronted.

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NEW MINES AND QUARRIES

Kyanite Mining Corporation's new Willis Mountain plant, located near Dillwyn, Buckingham County, has been completed and is in full production. The plant more than doubles output of kyanite concentrates from the corporation's other plants. Mining is quarry type with froth flotation as recovery method. By-products are sand and gravel.

Tri-State Zinc, Inc. began mining zinc from its underground mine near Timberville, Rockingham County, in March. The operation is the culmination of a program that began in 1951, when the company started exploratory work in the area. The company concentrates zinc at the mine, milling 720 tons per day. Concentrates are shipped to smelters at Monaca, Pennsylvania. Tri-State Zinc, Inc. also mines lead and zinc near Galena, Illinois.

Graham Virginia Quarries, Inc., in May, began producing crushed stone from its new quarry in Fairfax County near Occoquan. The plant is producing approximately 2,000 tons per day but has a capacity of 500 tons per hour.

Broken Hill Stone Corporation recently opened a quarry in Triassic sandstone near New Baltimore, Fauquier County. The corporation produces building stone and flagstone.

In March, Superior Stone Company reopened its quarry, in Louisa County near Gordonsville, which had been worked for a short time in 1954. The company produces about 800 tons of crushed stone per day from this operation.

Superior Stone Company operates another quarry in Virginia, at Red Hill, Albemarle County, and operates quarries in North Carolina and Georgia.

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Pounding Mill Quarry Corporation recently opened a limestone quarry near Bluefield, Virginia. The capacity of the operation is 1,000 tons per hour, with production used as aggregate for concrete and road construction and as fluxstone for the steel industry.

Roanoke-Webster Brick Company began building a new plant at Somerset, Orange County, in January. The company will manufacture building brick of all kinds and sizes, including standard size, over-size, Roman and Norman brick. The raw material used will be shale and the initial operation will produce 500,000 brick a week, but the plant will have a capacity of 2,000,000 brick a week. Production is scheduled to begin this fall.

Metal & Thermit Corporation is constructing a new plant in Hanover County, near Montpelier, Virginia. The plant will start operations on October 1, 1957, processing rutile and ilmenite ore at the rate of about 50,000 tons a month.

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RECENT TOPOGRAPHIC MAPS

The following topographic maps have been published recently and are available from this office: Arcola and Brookneal. The Arcola map is published on a scale of 1:24,000 and has a contour interval of 20 feet. It is a 7-1/2-minute quadrangle covering portions of Prince William, Loudoun and Fairfax counties. The Brookneal map is published on a scale of 1:62,500 and has a contour interval of 20 feet. It is a 15-minute quadrangle covering portions of Halifax, Campbell, Charlotte and Appomattox counties.

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NEWS ITEMS

Mr. Robert S. Wood joined the permanent staff on August 16. He was formerly employed on a part-time basis before leaving for military service. His interest is in the stratigraphy of the Ridge and Valley province. Mr. Wood received a Bachelor's degree from Washington and Lee University and has done graduate work at the University of Virginia.

Dr. Jean Lowry, who has been in charge of the Wytheville office for the past 8 years, resigned August 21. The Wytheville office will be closed.

Mr. H. R. Hopkins is on educational leave and has been admitted to the graduate school at Cornell University, where he is working towards a doctorate in geology. He will return to full-time employment in June, 1958.

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SOAPSTONE STUDY IN ALBEMARLE, NELSON, AND AMHERST COUNTIES

The mapping of the soapstone belt from the Rockfish River southwestward for a distance of 30 miles has been completed on a scale of 3 inches to a mile by H. R. Hopkins. This map has been placed on open file and blue-line prints are available at cost. The map delineates the different rock types in the belt and shows the areas in which commercial soapstone is most likely to occur.

Mr. William Fairley of Alberene Stone Corporation is mapping the soapstone belt from the Rockfish River northeastward to Alberene. When this area is completed, the soapstone mapping project will be concluded.

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