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Corps of Engineers U. S. Army

GEOLOGIC INVESTIGATIONS
WASTE DISPOSAL AREA
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE

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Ohio River Division Laboratories
Mariemont, Ohio

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INTRODUCTION

1. At the request of the Atomic Energy Commission, the Corps of Engineers conducted geologic investigations at the proposed location of waste disposal facilities. The general geology of the area was studied and eight "NX" size core borings were drilled. This report presents the results of the geologic investigation and an interpretation of the engineering significance of the geologic features.

GENERAL GEOLOGY

REGIONAL GEOLOGY:

2. The Oak Ridge area is located in the Great Valley of East Tennessee. The topography of the region is characterized by a series of parallel ridges and valleys which have a northeast-southwest trend. Bedrocks cover a wide range of geologic age and consist predominantly of shales and limestones. All rocks in the region have been subjected to great lateral pressures, which resulted in complicated folding and faulting of the formations.

3. With the exception of alluvial deposits along the flood-plains of streams, the soils of the region are residual. The residual weathering of shale is mainly a chemical process of decomposition. The resulting soils are generally lean clays. There is a gradual transition from the surface clay downward through a zone of rotten rock, weathered rock, and finally the fresh shale. With this in-place weathering process, the surface clays retain much of the original structure of the shale. The weathering of limestone is mainly a process of solution. The calcium-carbonate is taken into solution by percolating ground water, and is completely removed. The argillaceous impurities in the limestone are left behind to form a fat clay with little or no structure retained from the original rock. Over long periods of geologic time, the areas underlain by relatively pure limestone become valleys, whereas the shales and sandy formation form ridges. The transitional character of the residuum of shales is lacking in limestone areas where there is a sharp break from fat clay to relatively fresh rock.

SITE GEOLOGY:

4. The proposed area which was investigated lies between Haw Ridge on the northwest, and Copper Ridge on the southeast (Plate 1). The under-

lying bedrock is the Conasauga formation of Cambrian age. The area is located in a fault block between two major thrust faults. The Copper Creek fault is located at the northwest side of Haw Ridge. Underlying the Conasauga is the sandy Rome formation, which forms the crest of the ridge. Along this fault plane, the older Rome and Conasauga formations have been thrust up and over the younger Chickamauga formation. As a result of the great lateral pressures which developed the faults, the bedrocks are tilted, folded, and fractured by numerous joints and small secondary faults. The strike of the rocks (the line of intersection of a tilted layer with a horizontal plane) is parallel to the valleys and ridges, and averages about N 55° E. The dip of the rocks (amount and direction of inclination) varies from horizontal to vertical, but averages about 20° to 25° to the southeast.

5. Geologic literature covering this area treats the Conasauga formation as a single unit, although in other areas to the southeast, the formation has been subdivided into several distinct members on the basis of changes in rock type. As a result of these investigations and previous foundation investigations in the Conasauga at the Y-12 plant, the formation can be subdivided into four distinct types of rock. At the base of the Conasauga and overlying the older Rome formation, is a zone of dark red or maroon, silty shale with numerous thin beds or laminae of light green sandstone. This zone of silty, sandy shale is approximately 300 feet thick. Overlying this is a zone of dark gray, calcareous clay shale with numerous thin beds, lenses, and laminae of fine to medium grained light gray crystalline limestone. This zone is approximately 450 feet thick. Above this calcareous clay shale is a transitional zone of interbedded clay shale and shaly limestone. This interbedded zone is mainly shale at the base (toward the northwest) and gradually increases in the percentage of limestone at the top (toward the southeast). The upper and lower limits of this zone are more or less arbitrary, since the change in rock type above and below is transitional. The top zone of the Conasauga overlying the interbedded material is a zone which is predominantly limestone. Investigations in the waste disposal area were not extensive enough to develop the thickness and character of the zone of limestone. However, foundation investigations in the Y-12 area have shown that the base of the zone contains a light to medium gray fine-grained crystalline limestone with numerous thin beds of shale and paper-thin shaly liminations along bedding planes. The top of this zone is a light gray high calcium-carbonate oolitic limestone. In the Y-12 area, this zone is approximately 300 feet thick

1= P Valley
2= Rutledge + Rogersville + ½ Maryville
3: ½ Maryville + Nolichucky
Maynardville

ENGINEERING CONSIDERATIONS

TANK FOUNDATIONS:

6. In general, the surface of the area is blanketed by 2 to 4 feet of residual clay, and the underlying rock is badly weathered and decomposed to a depth of 15 to 20 feet. Because of the numerous tests that have been made on the same formation and similar materials in the Oak Ridge area, and because of the small loads to be applied to the foundation, no samples were obtained for laboratory testing. Test results on the same or similar materials from the Y-12 and K-25 areas have shown that the residual soils

(below the loose surface layer) are adequate to safely carry a load of 4,000 lbs/sq.ft. In the shale areas, the allowable bearing capacity increases with depth to a value of 12,000 lbs/sq.ft. in the moderately hard, unweathered shale. Since the anticipated foundation loading beneath the tanks is 3,500 lbs/sq.ft., even the residual clays near the surface offer adequate bearing capacity.

7. At the time of this investigation, the static water level in the drill holes averaged 10 to 15 feet below the surface of the ground. With this high water table, either sufficient weight or adequate drainage must be provided to prevent the tanks from floating.

8. It is believed that excavation in the zones of silty shale and clay shale can be accomplished by a power shovel without blasting to a depth of approximately 20 feet, or the base of heavy weathering. Below the zone of heavy weathering, the shale can be excavated with relatively light shooting. In the interbedded limestone and shale and the limestone zones, common excavation may be relatively shallow. The solution weathering of limestone leaves an irregular, scalloped surface. Pinnacles of hard limestone may extend almost to the surface. In any event, the limestone would require much heavier shooting than the shale.

9. If the contract for excavation is on a fixed fee basis, the government should not guarantee any depth of common or rock excavation. It is suggested that the field logs of the borings and the rock cores which were recovered be made available to the bidders for their own interpretation.

LEAKAGE CONSIDERATIONS:

10. In the event that pits in addition to tanks are used for waste storage, the possibility of ground water contamination through leakage becomes a definite problem which will require further investigation beyond the scope of the work covered by this report. The present investigation did not include any permeability or leakage studies, but several pertinent observations can be made on the basis of information obtained during drilling operations.

11. In all of the holes drilled, the cores obtained showed abundant evidence of joints and fractures throughout all types of rock. In some instances, these fractures were closed and cemented by secondary mineralization of calcium-carbonate. In others, the fractures were open and stained by the present migration of ground water. In all of the holes drilled, there was a small but steady loss of drilling water.

12. Silty Shale: Borings 1, 2, and 3 were drilled in the zone of silty sandy shale at the base of the Conasauga. At Hole No. 1, six feet of 3-1/2" casing was initially set in the hole, and core drilling was started in the badly weathered shale at a depth of 6-1/2 ft. Relatively fresh shale was encountered at a depth of 18.6 ft. During the drilling of

this badly weathered material, there was a constant loss of some drilling water. Examination of the soft cores recovered suggests that this water loss was along small fractures in the more sandy beds of the shale. When the hole was at a depth of 38 feet, a rough check on the water loss was made. The 3-1/2" casing was filled with water to the surface. After standing 1 hour, it had dropped to a depth of 15 feet below the surface and more or less stabilized at this point.

13. At a depth of 40 feet, a fault zone was encountered. This zone is believed to be a minor thrust fault branching off from the deeper, large Copper Creek Fault. This zone contained uncemented, more or less pulverized fragments of shale. When the fault zone was first penetrated, a small artesian flow occurred at the surface and lasted for approximately ten minutes. After that, the water dropped in the hole to a depth of 16 feet. At the completion of Hole No. 2, the casing was filled with water to the surface. The water level dropped from the surface to a depth of 6 feet in 45 minutes. From there, the drop in water level was very gradual. By the following morning, it had stabilized at a depth of 17.5 feet. Another small fault zone was encountered in Hole No. 3 at a depth of 27.8 feet. At this location, the stabilized water level was at a depth of 14.5 feet. The drop in water level from the surface to this depth occurred in about one hour.

14. Clay Shale: Borings 4, 5, and 7 were located in the zone of calcareous clay shale. At Hole No. 4, the depth of badly weathered shale is 16.7 feet, and in Hole No. 5 the badly weathered material extends to a depth of 20 feet. In both holes, open and stained fractures and bedding planes occur from the base of heavy weathering to a depth of about 30 feet. In the clay shale, it is believed that most of the water loss took place through these fractures beneath the layer of badly weathered rock.

15. Hole No. 7 was located in a valley of a small stream. The stream has cut down to rock in many places. During the drilling a heavy flow of drill water could be seen entering the creek along the top of rock about 75 feet downstream from the drill hole.

16. In this clay shale zone, the drilling information indicates that the top 15 feet or so of the badly weathered material is more impermeable than the same zone in the silty, sandy shale. There is evidence of leakage along fractures in the fresh rock and the possibility of heavy leakage in the transitional zone from badly weathered to fresh rock.

17. Interbedded Limestone and Shale: Borings 6 and 8 were located in the zone of interbedded shale and limestone. Hole No. 8 was located near the base of this zone and intercepted the underlying clay shale. The depth of badly weathered material at this location is 19 feet. Weathering along fractures, small solution channels, and bedding planes occurred to a depth of 25 feet. Approximately 8 feet from this drill hole was an old exploratory auger hole which was standing open to a depth of 18 feet. When the drill bit hit the relatively fresh limestone at a depth of 19 feet,

drilling water rose suddenly in the old auger hole and flowed out on the surface. This leakage was due to a connection between the holes along an open fracture or small solution channel. As drilling progressed, this connection was gradually sealed by drill cuttings being carried into the opening, and the flow between holes was eventually stopped. The water level in the diamond drill hole fell rapidly to 14.5 feet, but the water level in the auger hole dropped only one foot over night. This again indicates that the badly weathered material above the transitional zone into fresh rock is relatively impermeable.

18. Hole No. 6 was located near a small experimental waste disposal pit near the top of the zone of interbedded shale and limestone. Two observation auger holes had previously been drilled near the location. The holes are located in a triangular pattern with the diamond drill hole at the apex and the auger holes, both approximately 10 feet away. Numerous open and stained fractures, bedding planes, and small clay filled cavities were found to a depth of 25 feet; open and stained bedding planes, however, were found to a depth of 51 feet. Throughout the drilling, there was a rapid rise and fall of water in one of the auger holes following the water level in the diamond drill hole. The water level in the other auger hole was not affected. These observations show that leakage is generally along fairly open paths, that it can be rapid, and that it might be difficult to locate and trace. If the leakage occurred through a relatively homogeneous, permeable material, it would be an easy matter to trace the direction and rate of flow. However, with flow along a series of intersecting fractures, solution shannels, and bedding planes, tracing such leakage could be very difficult if not impossible.

19. Limestone: No holes were drilled in the limestone zone in the waste disposal area, but considerable information has been developed in the same zone in the Y-12 area. Near the base of the zone, in the shaly limestone, solution channels are numerous. Most of them are a foot or less thick, and most of them have developed along bedding planes. In the more pure oolitic limestone near the top of the zone, the channels are fewer but much larger. Channels up to 15 feet thick and extending at least 75 feet below the surface have been encountered. Such solution channeled limestone is notoriously bad from the standpoint of leakage.

CONCLUSIONS

20. As a result of these geologic investigations, the following conclusions have been reached:

a. Beneath the loose surface soils at a depth of two or three feet, any of the materials are adequate to carry the proposed load of 3,500 lbs/sq.ft.

b. Foundation excavation will be easier in the zone of silty shale and clay shale than in the interbedded limestone and shale or the limestone zones.

c. The permanent water table is so high that drainage of excavations will be required to prevent the tanks from floating.

d. Some leakage from pits can be expected in any of the rock or soil types in the area. The soils of the clay shale zone appear to be more impermeable than those of the silty shale zone, and both of these zones are superior to the limestone and the interbedded zones. Most of the leakage in the shale zones appeared to occur in the zone of transition between badly weathered and relatively fresh rock. This zone generally occurs at a depth of from 15 to 20 feet below the surface. If pits are dug to a depth of 15 feet, as proposed, there is the possibility that the bottom of the pit will be below the most impervious material and into a zone of leakage.

e. The zone of massive limestone (near Whiteoak Creek) is potentially the worst area from the standpoint of leakage.

f. Most of the leakage appears to be along open fractures, joints, and bedding planes in the rock. With flow along such channels, migration may be quite fast and for relatively long distances. These paths of leakage may be difficult to locate and trace.

RECOMMENDATIONS

21 As a result of the geologic information developed by this investigation, the following recommendations are made:

a. Because of the greater ease of excavation, shorter pumping distance, and more favorable conditions with respect to possible leakage, the storage tanks should be located in either the zone of silty shale or the zone of clay shale.

b. Before any large-scale use of unlined pits for waste disposal, a thorough hydrologic study should be made of the entire area.

c. If the pits appear to be feasible on the basis of the hydrologic studies, the pits should be as shallow as possible in order to preserve the maximum thickness of relatively impervious material between the bottom of the pit and the zone of open and stained fractures.