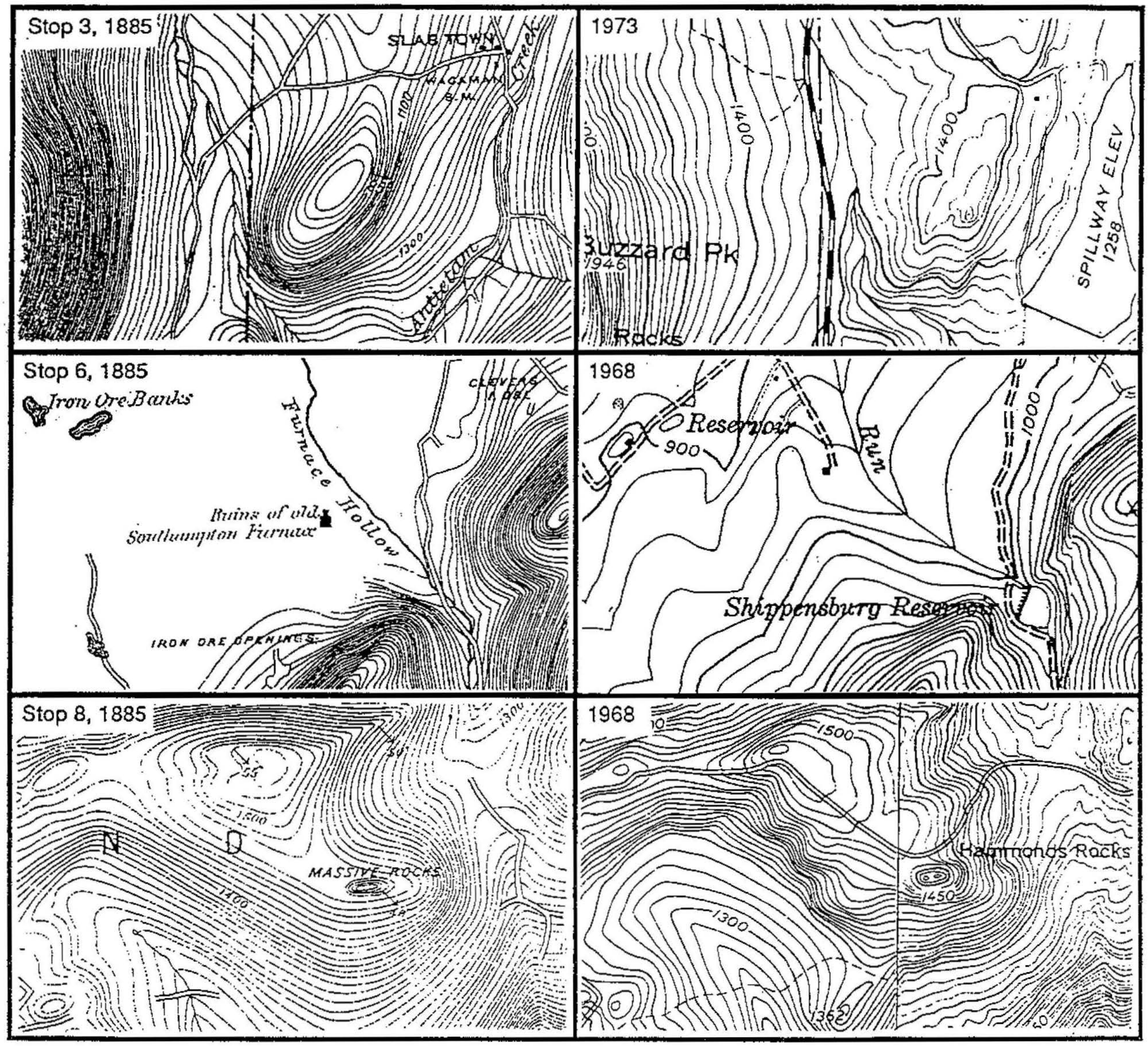
Guidebook

56th Annual Field Conference of Pennsylvania Geologists

Geology in the South Mountain Area, Pennsylvania



Hosts:
Dickinson College
Pennsylvania Geological Survey

September 26, 27, and 28, 1991
Carlisle, Pa.

EDITED BY W. SEVON AND N. POTTER

STOP 11. GEOLOGY OF THE PENNSY SUPPLY QUARRY, MT. HOLLY, PENNSYLVANIA

Discussants: Marcus M. Key, Jr. and Samuel J. Sims.

Directions. Go through the gate and straight past the metal building on the right and up the hill. The road swings around to the right and heads up hill. At the fork, take the outside (right) lane which leads to Bench 1. Come down the same way.

GEOLOGY

The Pennsy Supply Quarry (formerly the R. A. Bender and Son Quarry) is 2.5 km west-south-west of Mt. Holly Springs in Dickinson Township, Cumberland County, Pennsylvania (Figure 75). The

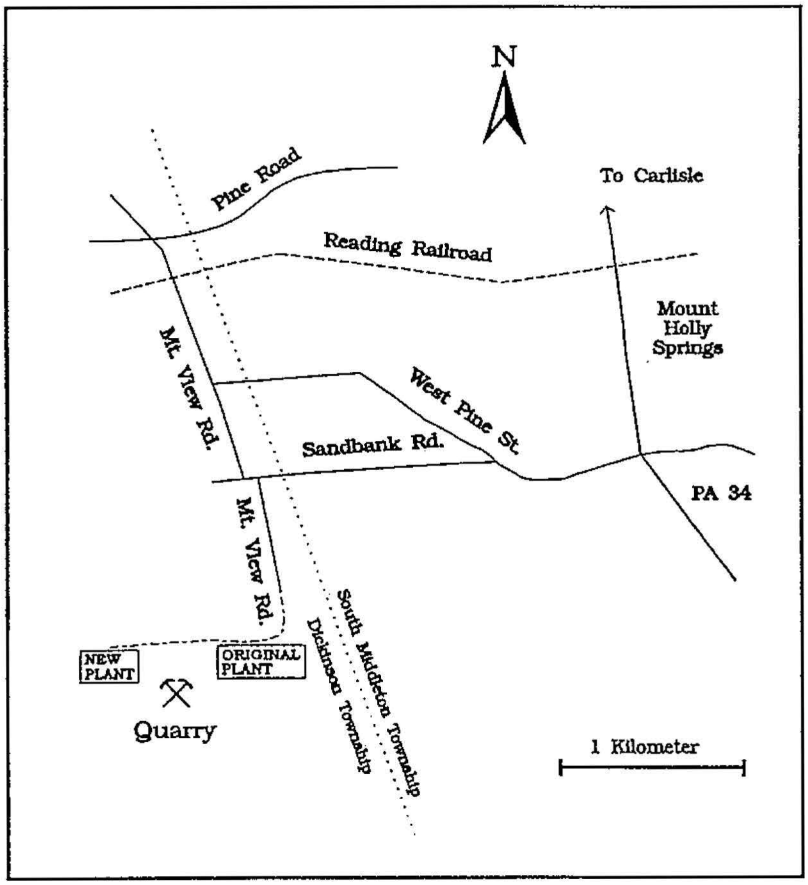


Figure 75. Map showing location of quarry.

quarry is on the northwest slope of Mt. Holly at the northeast end of the Blue Ridge physiographic province between the Great Valley to the north and west and the Piedmont to the south and east. The quarry exploits the Antietam Quartzite, which was deposited during the Lower Cambrian (See Key, this guidebook). The Antietam Quartzite was later folded during the Paleozoic Appalachian orogenies that formed the South Mountain Anticlinorium. The quarry straddles the axis of the Bender's Quarry Anticline (Freedman, 1967; 1968) which plunges gently to the northeast. The present quarry is in the northwestern limb of this anticline (Sims, 1985).

The Antietam Quartzite lies on the upper phyllitic member of the Harpers Formation and is overlain by the Tomstown Dolomite. The Harpers Formation crops out upslope (to the south and east) from the quarry while the more-soluble and easily-eroded Tomstown Dolomite forms the southern margin of the Cumberland Valley to the north and west. The Harpers Formation and Tomstown Dolomite do not crop out in the quarry. Based on the distribution of float and topographic slope changes, the Antietam Quartzite is estimated to be at least 440 feet thick in Mt. Holly (Freedman, 1967).

The lithology of the Antietam Quartzite that is exposed in the quarry varies greatly. Textures range from fine- to coarse-grained, subangular to subrounded, well- to poorly-sorted, thin-bedded to massive, with local crossbedding, laminations, and numerous *Skolithos linearis* worm tubes. Pre-deformation lithologies varied from thin clays, to quartz arenites, to granular quartz sandstones. Post-depositional deformation has altered these rocks to phyllites and quartzites. In some areas, slight schistose development is evident. The most common lithology is a relatively clean, massive, well-sorted, silica-cemented quartzite with up to 99 percent rounded quartz grains (Freedman, 1967; Fauth, 1968).

The *Skolithos linearis* worm tubes are ubiquitous in the Antietam Quartzite and are well illustrated in the slightly weathered, clean, indurated quartzites visible in the large blocks that have been set aside along the southwest edge of Bench 1 (Figure 76). Originally, these worm tubes had circular transverse, cross-sectional shapes. Because of subsequent stresses during the Appalachian orogenies, they have been deformed to a more elliptical shape. Measurements of the resulting strain on the cross-sectional shapes of four worm tubes reveals a ratio of the short to long axis of 0.61.

The lithology and structure of the Antietam Quartzite are difficult to see in the quarry because of the massive nature of some units and well-developed jointing and weathering. It is especially difficult to determine the orientation of bedding. Look at the cliff between Benches 1 and 2 (Figures 76 and 77) for bedding planes. There are two reliable indicators of bedding plane surfaces: (1) the presence of clay layers interbedded in the quartzites and (2) *Skolithos linearis* worm tubes perpendicular to bedding. The strike of bedding ranges from N60°E to N90°E, and dips range from 45°NW to vertical to 30°SE; the dominant jointing strikes N47°E and dips 38°SE (Figure 77). These joints have been

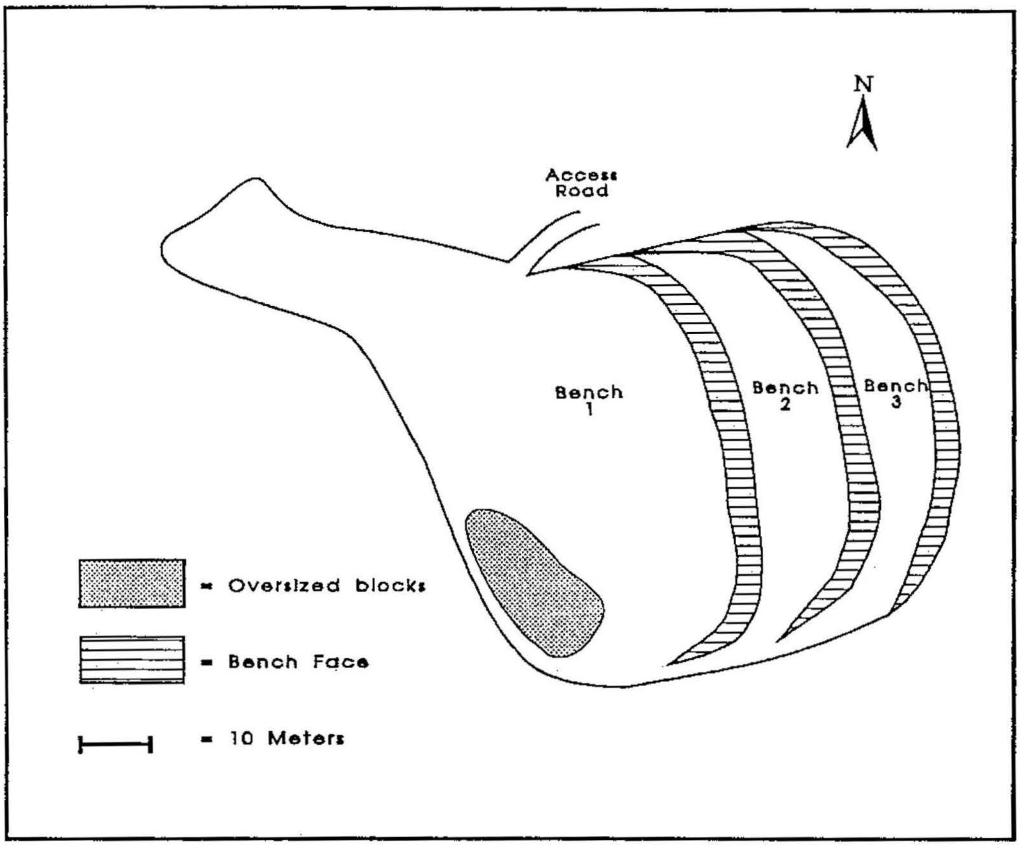


Figure 76. Diagrammatic plan view of active portion of quarry as it appeared in June, 1991.

interpreted as extension joints parallel to the regional trend of the Bender's Quarry Anticline (Freedman, 1967). The divergent attitude of the joints and bedding results in blocky exposures.

Weathering causes the Antietam Quartzite to become extremely friable with a yellowish-tan to pinkish-red color. In some places such as in the fault zone along the crest of the anticlinal ridge, weathering may extend down as deep as 40 to 50 feet (Freedman, 1968).

What caused this deep weathering? Freedman (1967, 1968) argued that it was caused by leaching of the silica cement. He hypothesized that the silica dissolution was due to percolating groundwater which became alkaline as it seeped down through the overlying Tomstown Dolomite (Freedman, 1967). This does not seem plausible due to the difficulty of leaching silica in non-tropical climates (Friedman and Sanders, 1978).

Another alternative is that the deeply weathered zones reflect a greater abundance of clay. To test this hypothesis, the type and relative abundance of clays in three Antietam Quartzite samples from the quarry were determined using X-ray diffraction. Results indicate that illite and kaolinite clays are present. The amount of illite is greatest in the clay layers interbedded between the quartzites, intermediate in the indurated quartzite, and least in the friable quartzite. The amount of kaolinite is greatest in the clay layers interbedded between the quartzites, intermediate in the friable quartzite, and least in the indurated

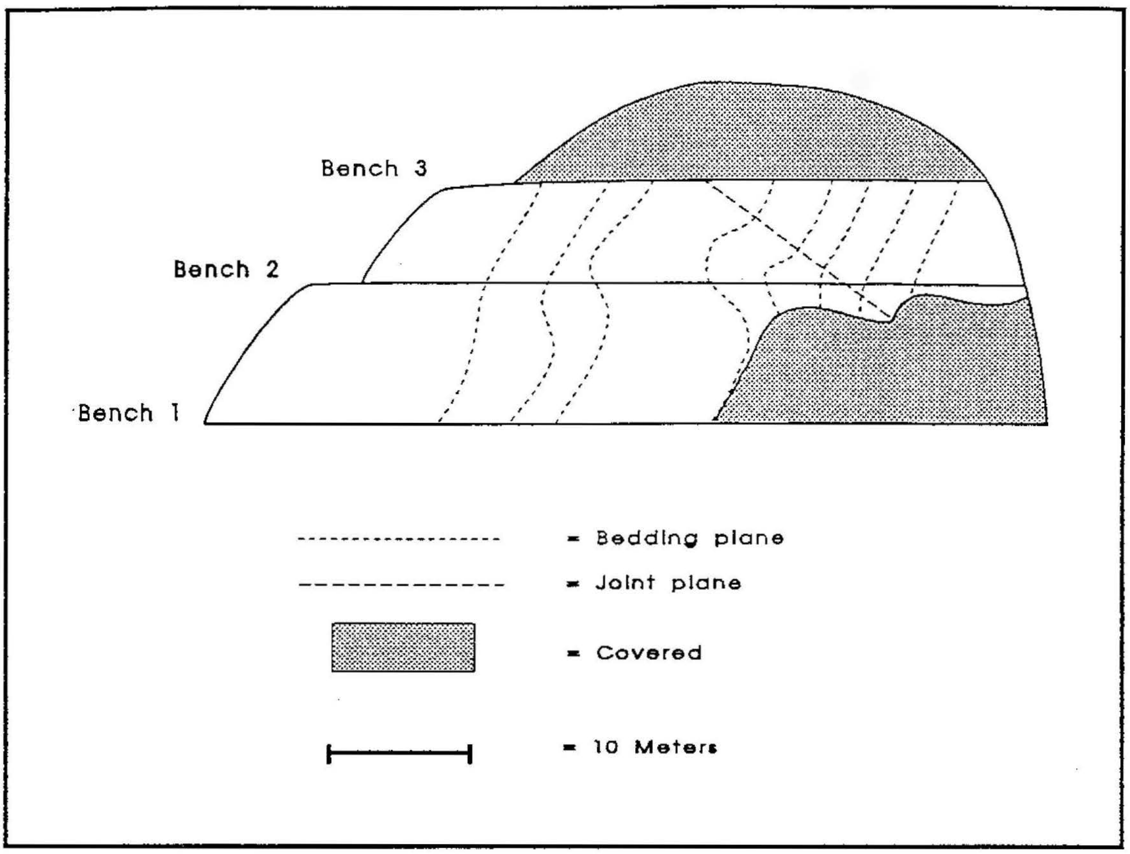


Figure 77. Diagrammatic cross section of Antietam Quartzite as it appeared in June, 1991 viewed from Bench 1 looking looking down strike (N77^{O}E).

quartzite. The interbedded clay layers are more commonly associated with the friable quartzite than the indurated quartzite. The deep weathering in some zones may simply indicate a greater kaolinite clay content. These deeply weathered zones are well known to the quarry operators because the clay-rich layers present a considerable problem of generation and disposal of slimes and are thus less desirable from an economic standpoint.

Spectacular liesegang rings are visible in the cliff between Benches 1 and 2 (Figures 76 and 77) as well as in the oversize blocks that have been set aside along the southwest edge of Bench 1 (Figure 76). Liesegang rings are secondary concentric rings formed by repeated precipitation within a fluid-saturated rock. Water in the once-saturated rock presumably transported iron in solution and precipitated it as hydrated iron oxide which we see today as rings of limonite. The liesegang rings found in the quarry are commonly formed around fractures in the quartzite. In the quarry, limonite can occasionally be found as pseudomorphs after another mineral, possibly pyrite. More commonly it occurs in botryoidal encrustations along fracture surfaces.

A problem is where did the iron come from because it is very rare in the Chilhowee Group. It may have come from dissolution of the overlying Tomstown Dolomite (Freedman, 1967). Dissolution of the Tomstown Dolomite has been associated with the economic iron deposits on the south slope of South Mountain (Stose, 1932). X-ray diffraction analysis of three Antietam Quartzite samples from the quarry revealed the presence of some dolomite or high magnesium calcite which may indicate dissolution of the overlying Tomstown Dolomite and reprecipitation in the Antietam Quartzite. This hypothesis implies that the leisegang rings formed when the Tomstown Dolomite overlay the Antietam Quartzite. How long ago did the Tomstown Dolomite rest on the Antietam Quartzite at South Mountain? The fact that Triassic rocks rest on Cambrian rocks in the Gettysburg Basin, suggests that the erosion of the lower Paleozoic carbonates in that area occurred before or while the Triassic rocks were deposited. If this is also true for the South Mountain area, then the introduction of the iron from the Tomstown Dolomite into the Antietam Quartzite had to occur before or while the Triassic rocks were deposited. This would mean that the liesegang rings are at least Triassic in age.

Another line of reasoning suggests that the introduction of the iron may have been associated with the deep weathering of the Antietam Quartzite during the Middle Tertiary or later (See Clark, this guidebook). Could there have been Tomstown Dolomite overlying the Antietam Quartzite in the Middle Tertiary? Erosion rates for this area shed some light on the question. Sevon (1989) calculated the present erosion rate for the Juniata River drainage basin as 27 m/Ma based on suspended and dissolved loads in the river. From previous studies, Sevon (1989) compiled a mean erosion rate for limestone in the eastern United States of 32 m/Ma. Using a value of 30 m/Ma and assuming erosion rates have not changed since the Middle Tertiary (15 Ma), the net amount of denudation since this time is roughly 450 m. If we project the Tomstown up 450 m, it would overlie the Antietam where the quarry is currently located. In fact the current elevation difference between the Tomstown in the Cumberland Valley and the Antietam at the top of the quarry is only 230 m. The problem with this kind of exercise is that we know that erosion rates changed radically in the past 15 Ma as the South Mountain area was exposed to glacial and interglacial climates (Braun, 1989). This casts doubt on our ability to predict the past position of the Tomstown Dolomite relative to the Antietam Quartzite, but leaves open the possibility that its removal is a relatively recent event.

Are there ~~other~~ sources for the iron other than the Tomstown Dolomite? The Antietam Quartzite in the Mt. Holly area contains iron-rich heavy minerals such as magnetite (Freedman, 1967). The weathering of these may have been the source of iron in the liesegang rings. The amount of iron-rich heavy minerals in the Antietam Quartzite at Mt. Holly is unknown. This may be relatively unimportant because very little iron is required to stain a rock with liesegang rings (Pettijohn, 1975). The liesegang rings may have formed in association with the deep weathering in the Antietam Quartzite itself. This may have occurred long after the Tomstown eroded away.

QUARRY OPERATIONS

The quarry is owned and operated by Pennsy Supply, Inc. of Harrisburg. The quarry produces sand, washed-sand, and fine-aggregate products for commercial use. The primary product is a concrete sand; other products are masonry sand, aggregate for concrete and asphalt, and general purpose sand and aggregate. There are two plants at the site for producing the range of products. The original plant that is nearest to the entrance to the quarry (Figure 75) has been upgraded and produces mainly masonry sand and sand approved by the Department of Environmental Resources (DER) for sand mounds for septic systems. This plant is a dry plant and consists of a primary jaw crusher, a secondary gyratory crusher, two sets of triple deck screens at 1 1/2 in., 3/8 in., and 5 mesh (4mm), a BARMAC impact crusher, and storage bins for loading directly into trucks or onto stackers for storage in stockpiles. The screens can be heated so that operation can continue during winter months.

The new and larger plant is both a dry and a wet plant sited to the west of the original plant (Figure 75). The dry part of the new plant consists of a primary jaw crusher, a secondary gyratory crusher, a BARMAC impact crusher, and triple deck screens set at 1 1/2, 1/2, and 3/8 inches. Material at minus 3/8 in. from the dry plant screens is fed to the wet plant that contains a triple deck wet screen set at 1/2, 1/4, and 3/16 in., an out-of-specification sand classifying tank, two screw classifiers, a cyclone, and a JADAIR clarifier. The main product from the wet plant is clean concrete sand, washed masonry sand, and clean fine Type A aggregate for asphalt that has a SRL rating of "E". The wet plant can be bypassed during cold weather, if necessary, to produce DER septic system sand, general purpose sand, and Type A aggregate. Products are conveyed to stockpiles by stackers around the plant and are loaded into trucks with front-end loaders.

The wet plant uses about 1,600 gallons of water per minute, which is supplied from a well that produces only about 100 gallons per ~~hour~~ minute. A well-designed recycling and storage program for plant water conserves almost all of the wash water. The JADAIR clarifier uses a flocculent to settle out the fine material in suspension that is fed from the classifier, and the clear water is recycled back through the plant. The flocculent is a polymer that neutralizes the naturally repelling cationic charges of the fine particles, which are then attracted to each other and flocculate and settle out of suspension (J. Kriz, personal communication, 1991). The slimes thus created are pumped from the clarifier as a slurry to settling ponds.

The quarry produces about 400,000 tons of product per year, about two-thirds of which is concrete sand. About 15 to 20 percent of the material quarried is lost as slimes and clay.

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