Geologic Atlas of the City of Alexandria, Virginia and Vicinity--Overview

By Tony Fleming, Licensed Professional Geologist, March 2008

Background

The City of Alexandria is included in a variety of small-scale, regional geologic maps and compilations, some of which date back a century or more, beginning with the pioneering work of Keith and Darton (1901) and continuing forward through the water-resources investigations of Johnston (1964), and culminating in a comprehensive study of the geology of Fairfax County by the US Geological Survey during the 1970's and early 80's. The latter eventually resulted in the publication of 1:24,000 geological maps of all of the topographic quadrangles partly or entirely in Fairfax County on the Virginia side of the river, except for the Alexandria Quadrangle, which encompasses the bulk of the city. The entire city does appear on a 1:48,000 preliminary compilation of Fairfax County (Drake and others, 1979), but the small scale of the map (the entire city appears within an area of approximately 6" x 6") and the limited number and wide spacing of reference features on the base map (it shows only a few major roads and drainages, and uses 50-foot topographic contour lines) limit its utility for most planning, engineering, and environmental applications. Likewise, a more recent compilation of maps by Froelich (1985), which focuses on the geology and hydrology of the coastal plain of Fairfax County, is at an even smaller scale (1:100,000), causing the entire city to fit into a map area less than 3" x 3". The lack of availability of modern, detailed geologic maps has been a significant limitation for the city, considering both the need for such information and how varied the geologic conditions are.

The Geologic Atlas of Alexandria was compiled specifically to fill this void. In addition to using a substantial amount of previously-collected geologic data, some historical in nature, the information contained herein was developed from a large amount of geologic and engineering data collected specifically for this project. The entire city was physically mapped, either on foot or by vehicle, and geotechnical boring records from more than 100 sites were collected. Many new exposures were visited, while the newly collected borehole information provided new insights into the subsurface distribution and behavior of different units. The maps in this atlas were developed by combining the newly-collected information with the historical information into a series of databases and cross sections that enabled several kinds of interpretations to be made. This approach differs from traditional regional geological mapping, which normally presents most or all of the interpretation of a given area on a single map. In this case, information is divided topically among several different maps, including one devoted exclusively to showing the sources and distribution of geologic data. In this way, it is hoped that specific kinds of information will not only be more easily accessible to users of the atlas, but also that the data used to compile it will be available to future studies in a readily understood, archival format. More than 40 new geologic units were mapped during the project, and an entire map is devoted to showing hydrogeological features of significance to water supply, water quality, ecology, engineering, and general environmental interest. As envisioned here, the maps and descriptions contained in the atlas could ultimately be integrated into the city's geographic information system, thereby making the information more readily available to a variety of city departments as well as businesses and the general public.

Contents

The atlas contains six main maps and diagrams, referred to as plates, which are listed below. All of the plates are produced at a horizontal scale of 1:12,000, or one inch to one thousand feet, which is twice the scale of a standard USGS topographic map.

Plate 1: Map Showing the Distribution and Sources of Geologic Data
Plate 2 (A-C): Geologic Cross Sections
Plate 3: Map Showing Bedrock Geology, Topography of the Bedrock Surface, and Altitude of the Base of the Potomac Formation
Plate 4: Map Showing the Geology and Thickness of the Potomac Formation
Plate 5: Map Showing Surficial Geology and Landforms
Plate 6: Map Showing the Piezometric Surface of the Cameron Valley Sand Member of the Potomac Formation, and Other Aspects of Urban Hydrology

In addition to the plates, which currently are only in paper format, the atlas includes a considerable amount of other geological data, all of which is archived electronically. All of these documents appear on the CD, and are organized as follows. Italicized listings are folders.

Databases

- -Alexandria exposures (MS-Excel)
- -Alexandria geotechnical borings (MS-Excel)
- -Alexandria USGS Wells (MS-Excel)
- -Alexandria soil sample locations and field descriptions (MS-Word)
- -*VDOT Woodrow Wilson Bridge-Capital Beltway Borings and Cross Sections* (contains cross section diagrams in PDF format, developed directly from VDOT's WWB-CB project website; see Plate 1-2-Expanded Explanation for a link to this website)

Map Explanations (Legends)

- -Plate 1 Explanation
- -Plate 2 Explanation
- -Plate 3 Explanation
- -Plate 4 Explanation
- -Plate 5 Explanation
- -Plate 6 Explanation

Expanded Explanations of Plates

- -Plate 1 and 2 Geologic Data-Expanded Explanation
- -Plate 3 Bedrock Geology and Topography-Expanded Explanation
- -Plate 4 Potomac Formation-Expanded Explanation
- -Plate 5 Surficial Geology-Expanded Explanation
- -Plate 6 Hydrogeology-Expanded Explanation

The "map explanations" are identical to the printed "legends" that appear on the plates, whereas the "expanded explanations" are narrative geologic descriptions that provide detailed information about the topic(s) encompassed by each plate.

How to Use This Atlas

Although all of the plates can and should be used together, each map also is designed to stand alone. In addition to the legend or explanation that appears with each plate, each plate also is accompanied by a separate document, called an "expanded explanation", where the map user can go to find much additional information and explanation of the features shown, including a discussion of the geologic history and processes that led to the particular deposits or features shown on the map, and a topical bibliography highlighting previous geologic work in the area and other relevant sources of information on the topics at hand.

For most map users and purposes, plate 5 will be the most useful and appropriate place to start. This map of "surficial geology" shows all of the different geologic units as they appear at the modern land surface and are distributed in the greater city landscape. These are the geologic materials that will be initially encountered by any activity or project involving the soil surface, for example, shallow excavations, surface-water hydrology, and horticulture. For water-resources and environmental applications, plate 6 provides additional hydrogeologic information that supplements the surficial geology; for example, the locations of wells and springs, the sources and locations of wetlands, and the direction of ground-water flow in the city's major aquifer. For many applications, these two plates will be all that is needed.

Plates 2, 3, and 4 provide greater detail about the subsurface. Geologically speaking, the city can be broadly regarded as a relatively regular series of strata that have been gently tilted to the southeast, and which have been covered at places by a host of less regular alluvial and slope deposits associated with the valleys of modern streams and the many hillsides that dominate the city's topography. Plate 5 shows all of these kinds of deposits as they crop out at the surface. Since many of the surficial deposits are relatively thin, it is sometimes useful to know what's underneath. Plate 4 depicts the geology of the Potomac Formation—the major series of coastal plain strata that immediately underlies the surficial deposits. Plate 4 was created by stripping all of the surficial deposits off of plate 5 to reveal what is below. The geology shown on plate 4 is based on a combination of outcrop data (as evident from plate 5, the Potomac Formation crops out at the surface at many places) and deep boreholes that penetrate beneath the veneer of surficial deposits to reveal the underlying geology. The Potomac Formation contains both sandy, clayey, and mixed-texture map units, hence it is of utmost importance for both ground-water resources and engineering. The amount of subsurface data available during this project allowed the Potomac Formation to be interpreted and subdivided at a level of detail not previously possible; major bodies of water-bearing sand and unstable clay, for example, were able to be delineated fairly reliably in many parts of the city.

The Potomac Formation, in turn, overlies the bedrock, which consists of ancient igneous and metamorphic rocks of the Piedmont, and which has been highly folded and deformed. Bedrock crops out only in the far western part of the city, in the vicinity of Holmes Run Gorge, but it is present everywhere beneath the younger strata, and contains many structures and features having potential significance to ground-water and modern seismicity. The buried bedrock surface also is a fundamentally important stratigraphic horizon in and of itself, in addition to its engineering and seismic significance. Plate 3

shows the bedrock geology and structure throughout the city, and is what you would see if everything above the bedrock surface was stripped off. In the large part of the city where bedrock is deeply buried beneath younger deposits, the geology and structure were deduced from a few deep boreholes, and from regional geophysical data available from the USGS, which typically strongly reflects bedrock structure, and extends into adjacent areas where the bedrock is well exposed.

Plates 2A-C are geologic cross sections that provide a three-dimensional view of the subsurface. Eighteen cross sections were constructed throughout the city, using a combination of borehole, water-well, and outcrop data to reconstruct the vertical profile of rocks, sediments, and ground water levels along each section line. The cross sections are oriented so that some of them follow the regional southeastward dip of the strata, whereas others run at right angles to the dip. Many of the sections follow major urban thoroughfares, such Seminary Road, Duke Street, and Shirley Highway, while others encompass more offbeat places, such as the natural areas near the far northwestern city limits. Virtually every part of the city is encompassed in at least one cross section.

Finally, plate 1 depicts the data that were used to construct the atlas. It shows the distributions and sources of each type of data, including surface exposures, historical water wells, geotechnical borings, excavations, and others. Each kind of data is referenced by a specific numerical identifier, and all data points are catalogued by type in the electronic databases noted above. Each database entry provides a brief description of the key geologic features or information associated with each data point. The map of data sources is particularly useful for getting a sense of the reliability of geologic contacts and other interpretations shown on the maps: reliability is greatest in places having a large concentration of data points, and least where data are sparse. Along with the associated databases, plate 1 also acts as an archive of the data collected for this study, and may prove useful in the future to others who are carrying out geological research or other types of investigations benefitting from geologic information.

Terminology and Conventions

An attempt was made to avoid using highly technical jargon in the atlas, but geology being a technical science, some use of terminology specific to both the science and the geology of Alexandria is unavoidable. Specialized technical terms that may not be familiar to most readers are typically explained where they are first used. More popular geologic terms that are likely to be familiar to most atlas users, such as “granite”, “sand”, and “oxbow”, need no further elaboration.

Geology deals with a vast amount of time, measured in many millions of years. The Potomac Formation, for example, was deposited during some or all of the early Cretaceous, which began some 144 million years ago, whereas the oldest rocks in Alexandria may be greater than 600 million years old. Ages of rocks, sediments, and landforms are typically stated in terms of millions of years. The abbreviation commonly used is, for example, 144 ma. Likewise, the Pleistocene, or Ice Age, spans the last one million years, and is divided into several substages whose ages are measured in thousands of years, abbreviated as, for example, 150 ka. Both of these abbreviations appear

frequently herein. One other useful abbreviation is “ybp”, which stands for “years before present” and is used in connection with Pleistocene events and stages.

Acknowledgments

This project succeeded because of the help and encouragement of several agencies and individuals. Major support for the project was provided through the Horticulture and Natural Resources Section of the Department of Recreation, Parks, and Cultural Activities. Rod Simmons and John Walsh of that group were closely involved with the project throughout and provided invaluable technical and logistical support. Rod led many field outings to interesting and important geologic, ecologic, and historical sites, and on numerous occasions acted as chauffer while I made observations of the Alexandria landscape. Kenneth Simmons, also of the same section, provided essential guidance to key field localities and vegetation communities. Several other city departments generously provided access to their files of geotechnical and engineering reports, and to their facilities, including Transportation and Environmental Services (T&ES), Planning and Zoning, and Alexandria Public Schools. The assistance of Shanna Sizemore, T&ES site plan coordinator, Greg Tate, former T&ES site plan coordinator, and Kendra Jacobs, Senior Planner, is gratefully acknowledged. Mark Krause, Director of Facilities for Alexandria Public Schools was instrumental; his encyclopedic knowledge of past school projects led to many geotechnical reports that provided crucial data in places otherwise lacking subsurface information. Ray Tudge, Thomas Wong, and Carlin Hall of VDOT facilitated the acquisition of major sets of geotechnical borings for the Capital Beltway and Shirley Highway. Thanks also to Brett King and Jason Agatone of the city’s GIS Division for providing detailed topographic and orthophoto maps of the field area.

References

Drake, A.A., Jr., Nelson, A.E., Force, L.M., Froelich, A.J., and Lyttle, P.T., 1979. Preliminary Geologic Map of Fairfax County, Virginia. U.S. Geological Survey Open-File Report 79-398. Scale 1:48,000.

Froelich, A.J., 1985. Folio of geologic and hydrologic maps for land-use planning in the Coastal Plain of Fairfax County, Virginia, and vicinity. U.S. Geological Survey Miscellaneous Investigations Series Map (IMAP) I-1423. Scale 1:100,000.

Keith, A.A, and Darton, N.H., 1901. Description of the Washington quadrangle (DC-Maryland-Virginia). US Geological Survey Geologic Atlas, Folio 70, 7 p., scale 1:62,500.

Johnston, P.M., 1964. Geology and ground-water resources of Washington, D.C. and vicinity. U.S. Geological Survey Water Supply Paper 1776. 98 p. scale 1:62,500.