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THE NUCLEAR CONTROVERSY: THE VIEW FROM BRITAIN[1]

Lord Zuckerman[2]

ADVICE AND RESPONSIBILITY

If there had been no industrial revolution, if there had been no agricultural revolution, if there had been no revolution in the sciences which underlie public health, the poverty, burdens and hazards of the agrarian societies which characterized life in this island in the middle ages, and which still characterize life in a few remaining parts of the globe, would still be with us. These revolutions are subject to no brakes. The human world is committed by its scientific past, and it cannot escape whatever emerges from the scientific knowledge which the future will bring.

Obviously where social and political issues are affected by developments in new scientific knowledge, government necessarily has to seek advice from scientists who can speak authoritatively on the subjects concerned. But what once seemed like a fairly straightforward advisory process has in recent years become immensely complex. There is now a babel of voices tendering advice, with conflicting views shouted from all sides.

In spite of all the elaboration of the government's scientific machinery, the problem of providing scientific advice has, as I have said, become more, and not less complex. This is not just because of the rate at which new scientific knowledge now emerges. Nor is it because the applications of science now pervade every aspect of our social life. It is also because the daily press and the broadcasting services are continually bombarding the government, parliament and the electorate with comment about scientific and technological matters, with the result that official advice is now almost always tendered against a background of well-publicized, but not infrequently superficial, fact and opinion. This is one of the paradoxical consequences of our new age of science. How can we now define expert advice? Self-appointed experts tell us that the world's physical resources will soon be exhausted, that nuclear power is too dangerous to develop, that saccharin can induce cancer, that the pollution of the atmosphere is leading to widespread ill-health. Without declaring their "credentials," they pontificate about nuclear power, or nutrition, or the environment. In almost every area of scientific interest, it becomes difficult to sift responsible from irresponsible advice, or to prevent public knowledge about science which should be dispassionate, from becoming overwhelmingly tinged by emotion, or even assuming some political intent.

EXPECTATIONS

As we all know, expectations of progress now have the habit of becoming social needs, and needs in turn become transformed into political demands or what has been called entitlements. Anything that becomes a

1 Reprinted from *Weekly Energy Report* (vol. 3, no. 12, March 24, 1975), 1239 National Press Building, Washington, D. C., 20045 by permission.

2 Lord Zuckerman is one of England's most respected scientists and is a former Science Adviser to the British government. This article is excerpted passages from his lecture *Advice and Responsibility* delivered as part of the Romanes series at the University of Oxford.

want, anything that someone else enjoys, has to be provided by the abstract entity called society. There are those who even write and speak as though we were born to live in a "no-risk" society, in some new Garden of Eden, created out of scientific knowledge, and in which all is peace and fulfillment.

Advising about matters of human safety and risk can rarely be more than an empirical and arbitrary exercise. There is, for example, no sharp line which separates a matter of quantity. An excess of nitrogen can kill, but so too can an excess of oxygen. Everything depends on the level of risk that people are prepared to accept. The setting of standards becomes even more arbitrary when it is influenced by irrational public pressure—as in the case of much that is said in the name of environmental protection.

LEGISLATION

We in the United Kingdom had already enacted a good deal of useful environmental legislation in the 50s and early 60s, but we nonetheless found it impossible not to become engulfed in the worldwide wave of enthusiasm for the protection of the environment which later started rolling, mainly in the United States and in Sweden. Almost every advanced country reacted. In 1972 we had the United Nations Stockholm Conference on the Environment, followed by the establishment of a permanent UN Agency to concert international efforts to prevent the spoliation of land, and the pollution of the air, rivers and seas.

It is obvious that all responsible people recognize that as much as possible should be done to protect our surroundings and to preserve the wild fauna and flora of the world. But by the time the UN agency was founded, some of us had already become worried by the fact that enthusiasm was outrunning itself. It began to look as if the economic and social costs of doing many of the things which were increasingly demanded in the name of environmental protection, mainly by pressure groups which were then springing up like mushrooms, were out of all proportion to their possible benefits. The whole movement then started to assume a protectionist and negative look under the banner of pseudo-scientific ecology.

But in the real world, we have to differentiate clearly between what is unacceptable from the point of view of amenity, landscape and preservation, from what is dangerous to health. Equally we need to distinguish possible dangers to health because of local conditions, from what may be dangerous to health because of general effects on the environment. Above all, possible risks always have to be judged against the cost and potential social benefits of their elimination. It needs to be said therefore that even though they may have been set either by WHO or by national authorities with the help of expert advice, few environmental standards have a truly scientific foundation.

Fortunately, differences of scientific opinion about the dangers of, say, lead or SO_2 in the atmosphere have not had any adverse effects on human health.

Given his concern with what may be hot news and what will appeal to the public, why should we expect the average popularizer of science to be overcautious? Yet he plays a far more important part in moulding public opinion about scientific matters than does the researcher who publishes his findings in professional journals.

NUCLEAR POWER

The public at large knows that there is enough science and engineering to land men on a precise spot on the moon. Why therefore should it not believe when the newspapers or television encourage, let us say, the view that nuclear power stations are so dangerous that those which exist should be shut down, and the construction of new ones stopped?

In general scientists are as deeply aware of their social responsibilities as are any other professional men. They know that world politics have been transformed by nuclear weapons, by space travel, by antibiotics, by modern pesticides, and by countless other scientific developments. Some have joined together to form societies with the laudable aim of keeping scientists alive to the fact that some kinds of discoveries can result in harm rather than good.

The development of nuclear energy has now become a field of dispute which is constantly in the press, and its outcome will undoubtedly help determine all our futures. The main points at issue are the safety of nuclear power stations, the toxicity and handling of plutonium, and the disposal of the radio-active products of fission. I shall say little about the arguments regarding safety.

My own belief is that those who have spent years designing and managing nuclear power stations are far more aware of the possible dangers and of the effectiveness of the safety measures required than are those who comment from the sidelines. It would be difficult to point to any branch of engineering which is more safety-conscious and more responsive to need than is nuclear engineering.

PLUTONIUM

Plutonium, about which I wish to speak particularly, is an element which is produced in reactors that generate power through the fission of the uranium atom. It is one of the most toxic radiochemicals known, and specific limits for the amount which the body can hold and for its concentrations in air and liquids were recommended as early as 1951 by the International Commission on Radiological Protection, on which always sit the world's best authorities on the subject. The basic standards which were defined are periodically reviewed, not only for people who run the risk of being exposed to ionizing radiation—from plutonium and other sources—when at work in nuclear plants, but also for members of the general public who might be exposed to particles of plutonium that could be accidentally released into the environment. Needless to say, the authorities in different countries collaborate in assessing the adequacy of these standards, and in reviewing any new evidence which bears on the subject. The results of the work of the International Commission and that of national authorities on radiation are open for all to study. Nothing is kept hidden.

Public concern about radiation became acute during the 1950s when it was realized that the testing of nuclear bombs either at ground level or in the atmosphere resulted in an increase in background radiation levels, and in the absorption by living tissue of radioactive chemicals. The alarm which was aroused then led not only to a widespread campaign for nuclear disarmament, but also to the international negotiations which culminated in the Partial Test Ban Treaty of 1963. As always, however, one set of alarms sparked another, and questions started to be asked about the potential problems which were involved in the disposal of radioactive waste from reactor nuclear fuel.

Concern was also aroused by the realization that the multiplication of reactors around the world would lead to the production of relatively vast quantities of plutonium, and so to the possibility that some of the material could fall into undesirable hands for the fabrication of nuclear weapons. This fear was far from allayed by the Non-Proliferation Treaty of 1968. Then came the force of the "environmental movement," with "citizens' groups" protesting against nuclear reactors being built, not only in populated but even in remote areas. Finally, the issue boiled over when A.R. Tamplin, an American biophysicist who had formerly been employed by the U.S. Atomic Energy Commission, joined forces with a nuclear physicist named Thomas Cochran in order to challenge the Atomic Energy Commission's protection standards governing the amount of plutonium to which members of the public could safely be exposed.

Tamplin's and Cochran's calculations had led them to the conclusion that the official American standard was 100,000 times too lax. Concern has reached a stage when one can justifiably talk about a determined campaign to close down the whole American nuclear power program, regardless of the effects this would have on the energy prospects of the country as a whole.

Not surprisingly, other groups of U.S. scientists have got together to oppose the anti-nuclear lobby. A public statement was recently put out by a group of 34 American scientists, among them 11 Nobel prize winners in physics, and all of them men competent to speak on the subject. The initiative to issue the statement was taken by Hans Bethe, one of the most distinguished nuclear physicists in the world.

The manifesto makes no attempt to minimize the risks associated with the generation of power in nuclear reactors, but it correctly points out that there are hazards in every other form of energy release. In the view of the 34 signatories, there is no reasonable alternative to an increased use of nuclear power if America's energy needs are to be satisfied. They also hold that there is no reason to question the ability of the nuclear industry to deal with the difficult problems of the transport and disposal of nuclear waste.

Immediately this powerful document appeared, Ralph Nader, the much publicized, self-appointed champion of the American consumer and the environment, put out a counter-statement. Some time before, he had started a lawsuit aimed at the shutdown of nearly all the nuclear power stations in the United States.

Nader's kind of protest movement is, of course, contagious. Only a few days ago it was reported in the press that some 400 French scientists had petitioned their government along the lines of the Nader protest. How many of them were nuclear physicists or engineers was not, however, stated.

We have seen nothing on this scale in the United Kingdom, but there have been echoes. For example, letters and articles have appeared in the press suggesting that our own authorities have been both complacent and evasive about the number of cases of leukemia that have occurred among nuclear workers at the Windscale reactor. There also is a public plea from a man who works at Windscale asking "that the media present a fair and balanced picture and compare our record of safety with those of other industries such as the mines, North Sea oil, the building industry, etc." He sees the press as intent on painting the nuclear industry as constituting "a dangerous, death-ridden occupation intent on destroying the environment."

If one accepts the fact that man is mortal, and that there is a risk of accidental death or injury in all we do, it stands to reason that comparisons of the kind this

Windscale worker advocates are essential if one is ever to get the scale of risk of a nuclear power plant into perspective. In fact, figures have recently been published showing that operational conditions in a nuclear power station are much less hazardous to health than those in a coal-fired power station. Authoritative figures also are available for other industries, and these have been taken into account in an official report on plutonium which the Medical Research Council has just published. The report notes that so far "there has been no cancer in man which can be confidently attributed to plutonium."

It also declares that the scare raised by Tamplin and Cochran about the enormous dangers of so-called "hot particles" of plutonium has no basis in evidence, and in the Council's judgment the occupational risk run by people working in nuclear power stations is probably about half-way between those of relatively safe and relatively unsafe kinds of non-nuclear industrial work. Setting aside the remote possibility of a disaster, the general public is not at risk at all.

As the report also wisely reminds us, two independent kinds of criteria are involved in the assessment of risk—first, the level of risk associated with a particular process, and second, a judgment whether that "level of risk is acceptable in the light of the accruing benefits to the individual and the nation." Whatever the industry involved, the first of these issues will always be a technical question which can be answered only by experts.

I myself have no doubt, any more than did the distinguished group of men who subscribed to Hans Bethe's statement, that the whole world, and not just the United States, will have to pursue the potentials of nuclear energy. The opponents of the U.S. nuclear power program have never suggested any viable alternative. This does not mean that I would not at the same time advise the utmost use of coal to help us through the economic dangers with which major parts of the industrialized world are not contending, even if this were to mean some temporary relaxation of environmental standards. There are other marginal energy possibilities, too—marginal in the relevant time context—which need to be pursued. But by any reckoning, nuclear power cannot be sidestepped without disastrous consequences.

I also share the belief that there is enough technical ingenuity and enough of a sense of responsibility among nuclear engineers to make us confident that no problem of safety will be left unsolved. After all, man's technical ingenuity has made space travel possible, has allowed us to control the activities of robots which we place on the moon, or which we command to photograph the planet Jupiter, hundreds of millions of miles away. If he is equal to such tasks, why should we doubt the engineer's ability to manage nuclear power plants?

Equally, I have sufficient faith in the Medical Research Council to accept their views about the dangers of plutonium rather than those of the two American dissident scientists and of an unofficial Natural Resources Defense Council of which they now appear to be the mainstay. I find it inconceivable that the American authorities would not have acted immediately if there were any grounds for suspecting that their standards were 10 times too lax, leave alone 100,000 times.

NEW PUBLICATION

Report of Investigations 38. GEOLOGY OF THE STUDLEY, YELLOW TAVERN, RICHMOND, AND SEVEN PINES QUADRANGLES, VIRGINIA, by Paul A. Daniels, Jr., and Emil Onuschak, Jr.; 75 p., 25 figs., 5 tables, 1974. Price $7.00 (plus 4 percent State sales tax).

The Studley, Yellow Tavern, Richmond, and Seven Pines quadrangles are located in Hanover, Henrico, and King William counties and the city of Richmond, almost entirely within the Coastal Plain province but with a small part in the Piedmont province. Stratigraphic units range in age from Paleozoic through Holocene, and include the Paleozoic Petersburg granite, Triassic "red beds," Lower Cretaceous Patuxent Formation, and several Upper Cretaceous(?)-Tertiary-Quaternary sedimentary formations.

Crushed stone, sand and gravel, clay for brick, and molding sand have been produced, although only sand and gravel is currently being quarried. Potential mineral resources include crushed and dimension stone, sand and gravel, clay for tile or face brick, glauconite and shell beds for fertilizer, shell marl for agricultural lime, and diatomaceous earth.

The report includes 13 maps: (a) four maps in color at the scale of 1:24,000 (1 inch equals approximately 0.4 mile) showing surface geologic units and (b) three subsurface structure-contour maps, three depth-to maps, one thickness map, one map showing landforms, floodprone areas, and watersheds, and a natural-hazards map, all at the scale of 1:50,000 (1 inch equals approximately 0.8 mile).

UTILIZATION OF SUBSURFACE INFORMATION IN THE COSTAL PLAIN OF VIRGINIA

Recently, the Division of Mineral Resources published Report of Investigations 38 on the geology of central and northeastern Richmond and the areas northward to the south edge of Ashland and eastward beyond Seven Pines (see New Publication, this issue of *Virginia Minerals*). The report contains several kinds of maps that are not normally included in quadrangle reports. This article discusses the manner in which some of these and similar maps are constructed, and their practical use in the Coastal Plain of Virginia.

The Division has utilized subsurface information in a variety of ways for many years. Primary uses have been as supplemental data for the compilation of surface geologic maps or for the location and evaluation of ground-water supplies. In recent years, however, the Division has made increasing use of subsurface data for the mapping of lithologic units that are of potential economic or environmental importance.

The Coastal Plain is an area where subsurface mapping is of particular value. This is in part due to the many environmental geologic problems that can arise where several layers of relatively undisturbed and unconsolidated sediments overlie a "basement" of mixed rock types (igneous, metamorphic, and sedimentary). Also, in areas of poor exposures, particularly heavily urbanized areas, subsurface information becomes an increasingly important supplement to the available outcrop data for the construction of both surface and derivative maps. Derivative maps that show the shape of or depth to horizons of interest provide a basis for sound land use planning decisions. Construction of such constraint maps requires subsurface data.

As products for land-use planning, subsurface maps provide such information as the shape and thickness of geologic units. The following represent examples from the Richmond area publication (Report of Investigations 38): knowledge of shape, depth to, and thickness of principal aquifers allows water supplies to be more efficiently developed than would otherwise be possible; the depth to aquicludes (sealing layers) above the aquifers that provide protection from downward-percolating contaminants; and the presence of firm foundation materials and sensitive or unstable rock units for safe construction. Various thickness maps provide information as to the capacity or capability of certain rock units to provide water, or underground storage or disposal (for example, gas, liquid or solid waste). Subsurface maps also provide insight as to the "pollution potential" or susceptibility to contamination of a given zone.

SOURCES AND TYPES OF SUBSURFACE DATA

Subsurface information is obtained either from geophysical techniques such as gravity, magnetics, and seismic or by drilling with rotary or cable tool equipment. This article is concerned only with data derived from the latter ("downhole") methods. One primary component of "downhole" data is the collection of lithologic samples while drilling is underway. Sample recovery generally is from 10-foot intervals and consists of drill cuttings or cores. The samples and information on depth of collection and other pertinent data (for example, drilling location and elevation, penetration rates, and type of drilling rig) are contributed to the Division's repositories by drilling contractors or their clients.

There are several types and sources of subsurface information utilized by the Division of Mineral Resources: water wells licensed by the Virginia Department of Health, contractors submit samples to the State Water Control Board which in turn sends them to the Division for processing; stratigraphic tests drilled under contract to the Division, U. S. Geological Survey, or private companies; observation wells drilled under contract to the State Water Control Board (Bureau of Water Resources) or U. S. Geological Survey; oil and gas tests licensed by the Virginia Division of Mines and Quarries; foundations engineering borings from the Virginia Department of Highways and Transportation, private companies or individuals, and drilling contractors; and soil surveys from the U. S. Department of Agriculture Soil Conservation Service and Virginia Polytechnic Institute and State University Extension Service. This information commonly is received in several forms: lithologic samples (drill cuttings and/or cores); drillers logs; soils engineering logs and reports; geophysical logs including electric, gamma-ray, caliper, sonic, and formation density logs. The electric and gamma-ray logs are important tools for stratigraphic analysis, particularly when they can be calibrated to a set of lithologic samples.

ANALYSIS OF INFORMATION

Upon receipt of subsurface information, analysis begins with a quality control decision on the information's usefulness. Of particular concern is the accuracy of the drill site *location* and its *elevation*. Without this knowledge, accurate derivation of subsurface elevations is impossible. Sample frequency and condition also are important. Sample condition is primarily a function of the physical circumstances of collection, including type of drilling equipment used; type of sample, drill cuttings, or core; type of drilling fluid; competency of the sediments or rocks being drilled; and the condition of the test hole as to caving and other factors.

A second decision as to the geologic usefulness of the data is then made before finally selecting samples or logs for further analysis. Geologic considerations include the total depth of the hole and the lithologic units penetrated. Geographic distribution of control is also a factor.

Analysis continues with the microscopic study of any samples. From this examination the geologist records observations concerning the physical character of the rocks and sediments from various depths. Such observations include grain size, shape, and boundary relationships; color; mineral composition; structure (for example, bedding, deformation, layering, fracturing, and cleavage); rock quality; fossil content; matrix type and amount; or any other parameters deemed pertinent. These detailed descriptions of lithologic samples, known as geologic logs, provide the geologic criteria necessary for the definition of various lithologic units. For example, such criteria might include the *first* "downhole" appearance of a different lithology as indicated by mineral or fossil content. The depth of such an occurrence may represent the top of a particular unit of interest which would be recorded on the log. Analysis of test borings would include correlation of lithologic descriptions, "blow-counts" (standard penetrometer or other), and engineering test data to geologic logs from previously analysed wells, borings, or other information. Only after "formation tops" have been selected and plotted can geologic interpretation and subsurface mapping begin.

PRODUCTS AND APPLICATIONS OF SUBSURFACE INFORMATION

With the basic data assembled in usable form, the distribution of data for various horizons of interest is plotted in map and cross-sectional formats. Interpretive maps and cross sections are then constructed that show the three-dimensional relationships of this data. These maps, cross sections, and reports then are made available to potential users as publications of the Division of Mineral Resources. The utilization of these products following publication is most critical, however, because it is their application that will determine the value of the geological contribution and the effectiveness and efficiency of any planning or development efforts.

GUIDES FOR LAND-USE PLANNING

Subsurface maps can be very useful tools for planning purposes as many physical parameters can be shown in contour-map form. Consideration of geologic information in land-use planning is particularly important as generally the "best" land-use is the one which is in concert with the physical environment. Subsurface maps are of particular importance as aids to inventories of mineral resources, including indications of present and future availability of those resources, and as guides to potential natural difficulties to urban development. For construction of building foundations subsurface maps provide information as to the shape of the supporting horizon, depth to that horizon, and something about the stability and behavior of the materials. For water supply or waste disposal (liquid injection or solid), subsurface maps provide information not only on the first three factors but also on the thickness of the units, and the porosity and permeability or conversely the "sealing qualities" of a given unit. For example, structure-contour and thickness maps were used extensively in Report of Investigations 38 for the Richmond area. The maps were used to show the shape of and depth to the "basement" rocks that underlie the sediments with implications for stone quarrying or foundations, the Patuxent Formation that supplies large amounts of potable ground water, and a clayey silt unit that greatly affects both construction and ground-water distribution. A map showing the thickness of the Patuxent, an aquifer, is also included.

Subsurface maps are indicators of rock and mineral resources that have potential commercial value. This would be true in the Virginia Coastal Plain, for example, in regard to water; sand and gravel for aggregate; shell, marl, and greensand for fertilizer; clay for brick and other ceramics, and diatomaceous clay; nonmetallic and heavy minerals; and fuels.

The production of construction aggregate, in particular, has caused considerable land-use conflict. Subsurface maps furnish information for planning, zoning, and reclamation as well as provide a sound basis for the computation of resource economics.

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NEWS NOTE

Westmoreland Coal Co. plans to open a large underground coal mine in Wise County, southwestern Virginia. It will consist of a complex of drift entries with four seams — Low Splint, Taggart, Taggart Marker, and Wilson — to be mined. The cost to open the mine will be $20 million, and it is expected to start producing in 1977.

TOPOGRAPHIC MAPPING

Within the cooperative Commonwealth of Virginia-U. S. Geological Survey mapping program the following products are in progress: map revisions, orthophotoquads, slope maps, orthophoto maps, county maps, photomosaics, and quad-centered aerial-mapping photography. In the continuing program to update topographic maps in growth areas every 5 years or less, 67 7.5-minute topographic maps, mainly in the south-central part of the State, are being photorevised. The Richmond 1:250,000-scale map is being revised and compiled from the 7.5-minute series. In addition the 1:500,000 State base and topographic maps are being updated; the latter will also depict State parks and forests. Thirty-six orthophotoquads, which are rectified aerial-photograph depictions, are being prepared for the Culpeper, Front Royal, Hampton, Harrisonburg, and Richmond areas. Twenty orthophotoquads depicting Charlottesville, Dismal Swamp*, Fredericksburg, Front Royal, Gainesville, Leesburg, Luray, Waynesboro, and Winchester are currently available. Ten 1:24,000 slope maps, on which the inclination of the land surface is portrayed by percent categories, will be available for the cities of Fredericksburg, Martinsville, and Staunton. A slope map, scale 1:50,000, is available for Stafford County*. Orthophoto maps, which are a multicolor combination of a photographic image with topographic map information are being prepared for the Dismal Swamp and Wachapreague areas. County maps, scale 1:50,000, are in progress for Warren and New Kent counties; Stafford County is available. Photomosaics are available for the Dismal Swamp* and Stafford County*; those for Warren and New Kent Counties are in preparation. Quad-centered photography*, scale about 1:72,000, is available for north-central, south-central, and eastern Virginia; west-central and southwestern Virginia will be available by 1976. Each photograph depicts and is centered on a 1:24,000-scale topographic quadrangle. A 3-times enlargement* of such a photograph is a useful information complement to the quadrangle.

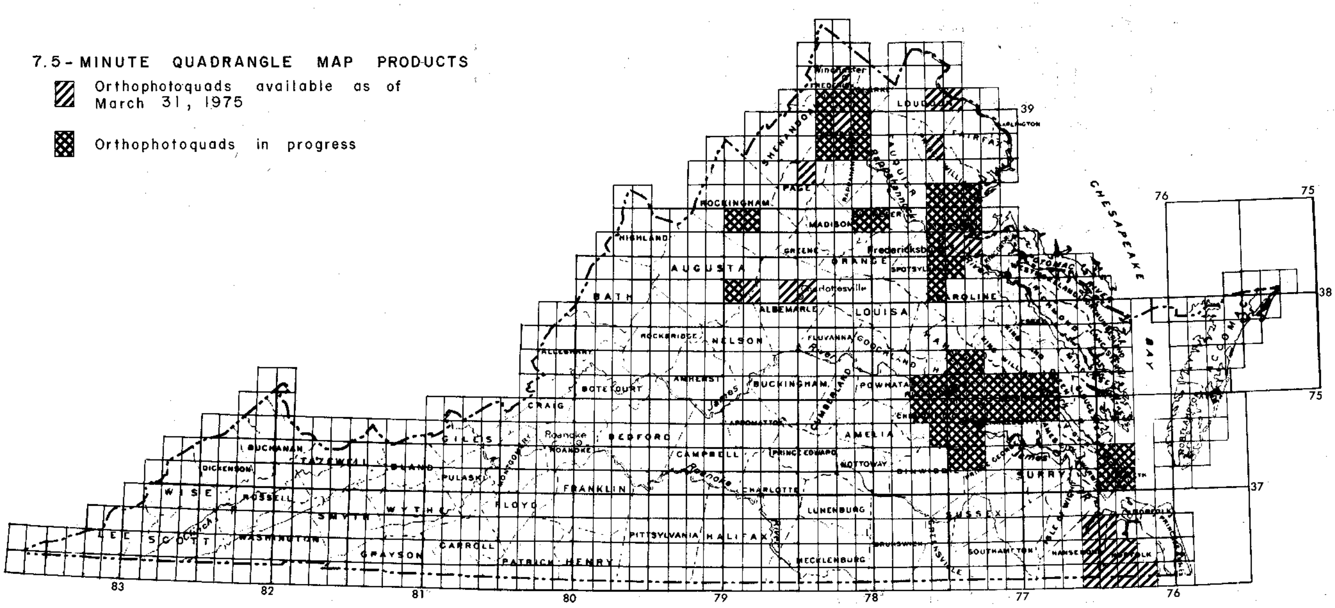
*Available as photographic reproductions only from the Eastern Mapping Center, Topographic Division, U. S. Geological Survey, Reston, VA. 22092.

Information on new map products in progress and on the cooperative mapping program is available. Listings of photorevised maps, quad-centered photos, and numbers and costs of maps to depict cities, towns, counties, planning districts, parks, forests, refuges, public fishing areas, rivers, and unique landforms can be supplied from the Division of Mineral Resources for individual requests.

AERORADIOACTIVITY SURVEY OF EAST-CENTRAL VIRGINIA

An aeroradioactivity survey that covers approximately 1,980 square miles in east-central Virginia was released on May 1, 1975 by the Division of Mineral Resources. The survey includes the following 15-minute quadrangles: Columbia, Dillwyn, Fredericks Hall (southern half), Glenora (all except the northeastern

ORTHOPHOTOQUADS



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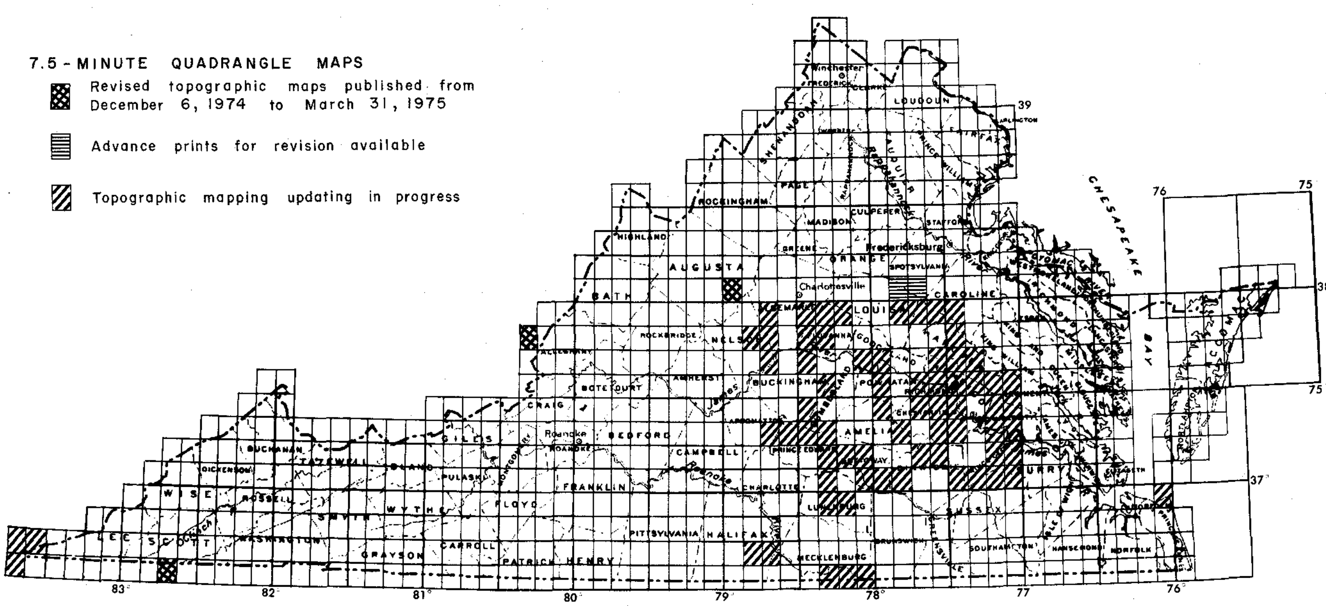
quarter), Gordonsville, Lakeside Village, Powhatan, Rapidan, and Sperryville.

The survey utilized a gamma-ray spectrometer that recorded the total count as well as the individual responses of potassium, thorium, and uranium. It was flown at 500 feet above ground level in east-west flight lines that were one-half mile apart.

The contour maps, which are on open file in the Division's library at Charlottesville, are available for reference use. Ozalid copies of the individual contour maps of each 15-minute quadrangle at the scale of 1:62,500 may be purchased for $5.20 ($5.00 plus $0.20 State sales tax) from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, VA 22903. An ozalid composite copy of the entire survey at the scale of 1:250,000 is available for $10.40 ($10.00 plus $0.40 State sales tax).

TOPOGRAPHIC MAPS



Revised 7.5-minute quadrangle maps published from December 6, 1974 to March 31, 1975:

Photorevised Maps
- Church Hill
- Waynesboro West
- White Sulphur Springs

Advance Prints for Revision
- Lake Anna East
- Lake Anna West

ADVANCE PRINTS

Advance prints are available at 75 cents each from the Eastern Mapping Center, Topographic Division, U. S. Geological Survey, Reston, Virginia 22092.

PUBLISHED TOPOGRAPHIC MAPS

Total State coverage completed; index is available free. Updated photorevised maps, on which recent cultural changes are indicated, are now available for certain areas of industrial, residential, or commercial growth. Published maps for all of Virginia are available at 75 cents each (plus 4 percent State sales tax for Virginia residents) from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Virginia 22903.