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OUR MINERAL HERITAGE — OVERINDULGENCE OR SELF-DENIAL[1]

Fredrick C. Kruger[2]

The recent book, "Affluence in Jeopardy," by C. F. Park, Jr., has captured the attention of many thinking laymen in our country, but how many of us professionals have been aware and concerned with the technical, political, and social implications of the supply and demand picture of our mineral resources?

MINERALS DIRECTLY EFFECT 40 PERCENT OF ECONOMY

In order to provide some frame of reference for discussing the minerals kingdom, a series of tables has been prepared. Table 1 summarizes the dollar value of the mineral fuels, the metallic minerals, and the non-metallic minerals produced and consumed in the United States and in the rest of the world in 1969.

Although the dollar value of all minerals produced does not appear to be really very significant in terms of total United States' gross national product of $940 billion, the 2.7 percent of GNP represented by minerals has a direct impact on 40 per cent of the economy and an indirect effect on 75 percent of the economy.

Fig. 1 graphs the production of all minerals in the United States over the last 25 years and shows several interesting features:

(1) The fuel minerals—petroleum, natural gas, and coal—completely surpass in value the total of all the solid minerals.

(2) The glamor sector, the metals—copper, gold, iron, etcetera—are in turn completely surpassed in value by the nonmetallics.

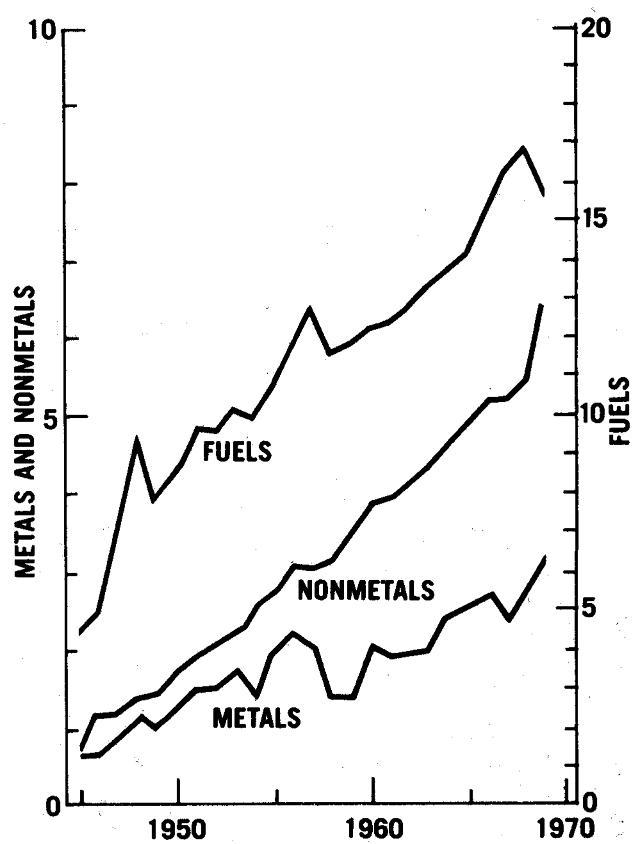

Figure 1. Value of United States mineral production (billions of dollars).

[1] Reprinted from *Mining Congress Journal,* August 1971.

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Table 1.—Summary of value of mineral production and consumption in 1969 (millions of dollars).*

	Production		Consumption	
	United States	Rest of World	United States	Rest of World
Fuels	$16,563	$ 52,881	$17,999	$ 51,445
Metals	3,471	20,580	6,343	17,708
Nonmetals	5,465	37,280	6,121	36,543
Total	$25,499	$110,741	$30,463	$105,696

* Estimate based on U.S.B.M., January 1970

Table 2.—Value of fuel production in 1969 (millions of dollars).

	United States	Rest of World
Anthracite	$ 93	$ 1,711
Bituminous	2,750	13,050
Gas	3,470	2,120
Petroleum	10,250	36,000
Total	$16,563	$52,881

* Estimate based on U.S.B.M., January 1970

Table 3.—Value of metallic mineral production in 1969 (millions of dollars).

	United States	Rest of World
Antimony	$ 1	$ 90
Bauxite	26	685
Beryllium	1	3
Bismuth	6	18
Cadmium	27	51
Chromite	0	> 216
Cobalt	20	> 88
Columbium-Tantalum	0	28
Copper	1,435	4,255
Gold	73	1,905
Ilmenite	20	44
Iron	920	6,410
Lead	158	824
Magnesium	75	78
Manganese	.3	510
Mercury	15	126
Molybdenum	169	68
Nickel	60	1,530
Platinum	4	475
Silver	72	428
Thorium	n.a.	> 8
Tin	.1	742
Tungsten	26	165
Uranium	175	125
Vanadium	23	33
Zinc	165	1,575
TOTAL	>$3,471	>$20,580

* Estimates based on U.S.B.M., January 1970

Table 5.—Production, consumption, and reserves of mineral fuels in 1969 (millions).

	United States			Rest of World	
	Production	Consumption	Reserves	Production	Reserves
Anthracite (tons)	11	11	14,942	208	large
Bituminous (tons)	547	505	825,189	2,588	1,634,312
Gas (mcf)	20,624	20,822	287,350	34,000	856,820
Petroleum (bbl)	3,362	3,882	31,000	15,160	391,000

Table 4.—Value of nonmetallic mineral production in 1969 (millions of dollars).

	United States	Rest of World
Asbestos	$ 10	$ 343
Barite	14	45
Borax	52	20
Cement	1,330	8,620
Clays	267	1,040
Corundum	0	0.5
Diamonds (industrial)	0	114
Diatomite	34	62
Feldspar	10	19
Fluorspar	8	174
Garnet	19	3
Gems	2	11,500
Graphite	.4	17
Gypsum	37	169
Kyanite	n.a	22
Lime	262	640
Lithium	5	4
Mica (sheet and scrap)	4	1
Olivine	n.a.	n.a.
Perlite	6	n.a.
Phosphate	240	312
Potash	76	404
Pumice	5	17
Quartz (crystal)	0	0.2
Rutile	n.a.	> 30
Salt	285	557
Saltcake	13	n.a.
Sand and Gravel	1,041	6,500
Stone	1,341	6,200
Strontium	0	0.3
Sulphur (native and recovered)	336	436
Talc	7	28
Trona	55	n.a.
Vermiculite	6	2
TOTAL	$5,465	>$37,280

* Estimates based on U.S.B.M., January 1970

SIGNIFICANCE OF NONMETALLICS UNAPPRECIATED

To give a further breakdown for comparisons, tables 2 to 4 show the dollar values of production for various individual commodities. It will not be surprising to see the positions of coal, natural gas, and petroleum, or of copper, gold, iron, lead, nickel, and zinc in our economy, but most people are unaware of the significant role of the nonmetallic minerals.

And now, turning to the heart of my subject, I wish to present a number of tables (tables 5 to 7) showing the production and consumption of mineral commodities in 1969, and their reserves, for both the United States and the rest of the world. The minerals tabulated include those commodities that dominate world trade in dollar value and tonnage and those that are considered to be of strategic importance and/or in critical supply (as designated by Congress). The estimates are based on information published by the U. S. Bureau of Mines. Where numbers are shown, they are based upon semi-quantitative geological and engineering data and there should be no serious disagreement about the reserves stated. Where non-quantitative appraisals as to size are used, we must accept the opinion of the individual commodity expert of the Bureau.

In general, the commodity specialists of the Bureau have considered today's reserves in terms of today's consumption rates to arrive at life spans for the various commodities.

These estimates deserve further comment. Some commodities, particularly among the nonmetallics, are so plentiful and so ubiquitous that there is no need to compile reserve data. There may be supply problems for specific grades or specific locations, but overall there are no critical problems.

The nonmetallics such as clay, lime, sand, gravel, and stone are large-bulk, low-unit value commodities that are sensitive to transportation, and therefore they have a "place value."

On the other hand, natural gas and petroleum are very mobile. Minerals like industrial diamonds, gems, gold, graphite, mercury, and sheet-mica occur in small quantities in limited areas and command such high prices that transportation is no problem. Others, like asbestos, borates, copper, iron, lead, phosphate, potash, salt, sulfur, and zinc, occur in large quantities in few geologic environments and command moderate prices, so transportation is not much of a problem.

Some minerals are co-products, such as silver with lead, or platinum with nickel, and some are smelting by-products like arsenic, antimony, bismuth and cadmium. For some of these minerals, it may be understood that accurate reserves estimates are difficult to compile.

U. S. NET IMPORTER OF MOST MINERALS

The United States is a substantial exporter of only four mineral commodities — molybdenum, phosphate, borates, and bituminous coal. It is a net importer of almost all other minerals. Those in which we are deficient and for which we must rely upon foreign sources have been placed on the strategic or critical supply list by Congress, and most of these have been assigned a depletion allowance of 22 percent (indicated by an asterisk in tables 6 and 7).

PER CAPITA CONSUMPTION IS PHENOMENAL IN U. S.

In order to assess the future demand for these mineral commodities, a number of trends and growth factors must be discussed.

Much that is necessary, and also perhaps unnecessary, has been written and said about the population explosion (see fig. 2). Our own nation's census will be about a third of a billion people by the year 2000, when the world's population will reach 6.5 billion. The world's growth curve for population is clearly steeper than that of the United States.

Tables 8 to 10 show the per capita mineral consumption in 1969 for the fuels, metals, and the nonmetals by the United States and the rest of the world. A meaningful figure for comparison is the ratio of the United States' per capita consumption of minerals to that of the rest of the world. In no instance does the rest of the world use more of any mineral than the U. S. In the cases of anthracite and, curiously, gem stones, the consumptions are approximately equal. In all other mineral commodities, the ratios of the present rates of consumption of various raw materials vary from about 2 to 100 or more, with the higher ratios among the nonmetals.

Perhaps this relationship may be illustrated more clearly with the summary of the total value of minerals consumed (as shown in table 1) and the per capita consumption (as shown in table

Table 6.—Production, consumption, and reserves of metallic minerals in 1969 (million tons).

	United States			Rest of World	
	Production	Consumption	Reserves	Production	Reserves
Antimony*	.001	.043	.1	.07	4.
Bauxite*	1.8	15.8	45.	48.6	8,255.
Beryllium*	.003	.01	n.a.	.008	n.a.
Bismuth*	.001	.001	n.a.	.004	ample
Cadium*	n.a.	.008	n.a.	> .01	ample
Chromite*	0.	1.4	8.	> 5.04	1,901.
Cobalt*	0.	.009	n.a.	.022	3.4
Columbium-Tantalum*	n.a	.003	.18	.01	8.9
Copper	1.56	2.0	85.	4.63	224.
Gold (oz)	1.7	6.7	75.	44.3	large
Ilmenite*	.95	1.3	100.	> 2.25	very large
Iron	86.	140.	10,494.	595.	239,855.
Lead*	.53	.78	35.	3.1	60.
Magnesium	.1	.1	infinite	.1	infinite
Manganese*	.01	2.3	small	>19.7	large
Mercury (flasks)*	.03	.08	.8	.25	4.5
Molybdenum*	.05	.04	3.1	.02	1.3
Nickel*	.02	.13	1.	.51	74.
Platinum (oz)*	.03	1.23	3.	3.57	421.
Silver (oz)*	40.	160.	1,320,	238.	4,280.
Thorium*	n.a.	.0001	.6	> .0008	1.2
Tin*	0.	.06	0.	.23	6.5
Tungsten*	.005	.006	.07	.03	1.2
Uranium*	.014	.016	.5	> .01	.8
Vanadium*	.006	.007	moderate	.009	large
Zinc*	.55	1.39	27.	3.1	90.

* strategic importance or critical supply

Table 8.—Per capita consumption of fuels in 1969.

	United States	Rest of World
Anthracite (tons)	.052	.055
Bituminous (tons)	2.523	.735
Gas (cf)	104,000	3.470
Oil (bbl)	19.41	3.16

Table 7.—Production, consumption, and reserves of nonmetallic minerals in 1969 (million tons).

	United States			Rest of World	
	Production	Consumption	Reserves	Production	Reserves
Asbestos*	.13	.79	moderate	3.33	large
Barite	.94	1.4	113.	3.02	83.
Borax	1.05	.82	120.	> .39	> 400.
Cement	77.	76.	large	499.	large
Clay	56.	56.	large	215	large
Corundum*	0.	n.a.	0.	.013	large
Diamond* (industrial, carats)	0.	18.	0.	30.	630.
Diatomite	.63	.48	large	1.16	large
Feldspar	.72	.72	large	1.45	large
Fluorspar*	.18	1.33	4.6	3.92	66.
Gems	$2.00	$452.00	n.a.	$11,048.00	substantial
Garnet	.02	.02	adequate	.004	large
Graphite*	.002	.05	large	> .46	enormous
Gypsum*	9.7	15.5	large	44.3	large
Kyanite*	n.a.	.1	30.	> .25	75.
Lime	20.	20.	ample	48.	ample
Lithium*	.003	.003	.73	.002	> .8
Mica (scrap)	.13	.13	large	.03	large
Mica (sheet)*	.00001	.003	small	.01	large
Olivine	n.a.	n.a.	n.a.	n.a.	n.a.
Perlite	.57	.4	large	n.a.	large
Phosphate	40.	26.	15,600.	52.	34,560.
Potash	3.	4.	460.	16.	130,600.
Pumice	3.33	3.	large	11.2	large
Quartz (crystal)*	0.	.0001	0.	.0002	n.a.
Rutile*	n.a.	.17	.5	> .43	n.a.
Salt	43.	46.	large	83.	large
Saltcake	.7	1.8	large	n.a.	large
Sand and Gravel	921.	920.	ample	6080	large
Stone	833.	833.	adequate	3850.	large
Strontium*	0.	.007	1.13	.012	n.a.
Sulfur*	8.4	9.2	305.	10.9	1,830.
Talc*	.98	.885	150.	3.985	very large
Trona	2.5	2.5	large	n.a.	large
Vermiculite	.3	.2	large	> .13	large

* strategic importance or critical supply

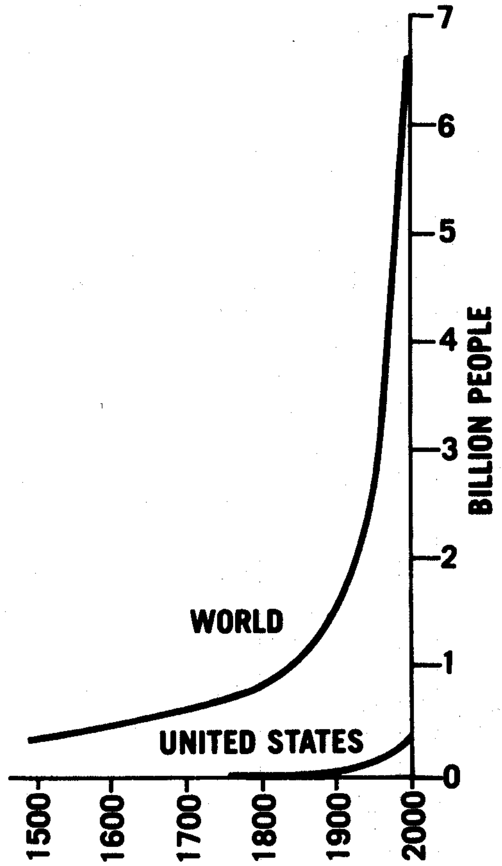

Figure 2. Population growth.

11). In 1969, each man, woman, and child in the United States used $152.32 worth of fuels, metals and nonmetals, whereas our counterparts in the rest of the world consumed only $29.60 per person. The full significance of these figures may be realized by considering the following "iffy" examples.

NEEDS WILL CONTINUE UPWARD SPIRAL

If the per capita rates of consumption for both the U. S. and the rest of the world remain constant at present figures, then the projected growth of population will demand almost twice the amount of present mineral production by the year 2000.

Or, with the unlikely assumption that if the populations will remain constant, and if we should glibly promise to raise the standard of living for the "rest of the world" to the present level of that of the United States, then the world's total output of minerals, now $136 billion, would have to be increased to $572 billion.

Or, if the standard of living in the United States remains constant and we attempt to raise the "rest of the world" to this standard by the

Table 9.—Per capita consumption of metals in 1969 (pounds).

	United States	Rest of World
Antimony	.4	.015
Bauxite	158.	19.4
Beryllium	.1	.0005
Bismuth	.01	.0017
Cadmium	.08	.005
Chromite	14.	2.04
Cobalt	.09	.01
Columbium-Tantalum	.03	.005
Copper	20.	2.35
Gold (oz)	.034	.011
Ilmenite	13.	1.06
Iron ore	1400.	303.
Lead	7.8	1.6
Magnesium	1.	.05
Manganese	23.	9.75
Mercury	.03	.004
Molybdenum	.4	.019
Nickel	1.3	.21
Platinum (oz)	.006	.0007
Silver (oz)	.8	.033
Thorium	.001	.0004
Tin	.6	.095
Tungsten	.06	.016
Uranium	.16	.0045
Vanadium	.07	.005
Zinc	13.9	2.48

year 2000, it would require $990 billions worth of minerals.

None of these hypothetical situations is likely to take place, but obviously the world's mineral needs will continue to spiral upward, and clearly few of the world's mineral reserves will stand this kind of a drain. Yet, as has already been recognized, the following trends are unmistakable:

(a) the inevitability of population growth;

(b) that most underdeveloped peoples tend to imitate us and tend toward westernization; and

(3) that per capita consumption in newly industralized nations has an exponential growth.

It is unavoidable that these trends pose problems in the management of our mineral heritage.

POSSIBLE SOLUTIONS FIT FOUR CATEGORIES

So much for the problems. What are the possible solutions? Those that immediately come to mind fall under four general categories: population control, conservation, new mineral discoveries, and new processing technologies. The first of these is outside of my field of competence, and yet is so obvious I shall not enlarge upon it.

The conservation of mineral resources brings to mind the following possibilities:

(1) The mining and processing of minerals could be done more efficiently, but these are already reaching irreducible minima because of intense competition in the industry.

Table 10.—Per capita consumption of nonmetals in 1969 (pounds).

	United States	Rest of World
Asbestos	7.9	1.48
Barite	14.	1.11
Borax	8.2	> .337
Cement	760.	280.
Clays	560.	120.
Corundum	n.a.	n.a.
Diamonds (industrial, carats)	.09	.0037
Diatomite	4.8	.73
Feldspar	7.2	.81
Fluorspar	13.3	1.27
Garnet	.2	.022
Gems (dollars)	$2.26	$3.22
Graphite	.5	.23
Gypsum	155.	21.7
Kyanite	1.	.14
Lime	197.	26.6
Lithium	.03	.0011
Mica (scrap)	1.3	.0168
Mica (sheet)	.03	.0039
Olivine	n.a.	n.a.
Perlite	4.	n.a.
Phosphate	260.	37.
Potash	42.	7.95
Pumice	30.	6.4
Quartz (crystal)	.001	.00064
Rutile	1.7	.145
Salt	462.	45.
Saltcake	18.	n.a.
Sand and Gravel (tons)	460.	1.7
Stone (tons)	417.	1.1
Strontium	.07	.0028
Sulfur	92.	5.65
Talc	8.9	2.28
Trona	25.	n.a.
Vermiculite	2.	.129

Table 11.—Value of mineral consumption per capita in 1969.

	United States	Rest of World
Fuels	$ 90.00	$14.40
Metals	31.72	4.95
Nonmetals	30.60	10.25
Total	$152.32	$29.60

(2) Lower-grade materials could be mined and processed, but consider this: A few years ago, Harrison Brown (whom the geologists call a chemist, and the chemists call a geologist) authored a best-seller in which he made the assumption that if energy were available at a cost approaching zero, then, he concluded, we could obtain all of our mineral needs from the constitutents of almost universal granite. However, what he neglected to consider were the vast quantities of unusable wastes that would be generated. For example, today, we handle some 500 million tons of rock to obtain our major metals, but Brown's proposal would require the handling of 10 billion tons! A very real problem in solids waste disposal.

(3) Political economists have traditionally attempted to solve this problem by turning to rationing and controlling prices to relieve the impending shortages.

(4) Of course, shortages of minerals will eventually bring on higher prices, and higher prices will presumably result in lower consumption, thus effecting conservation.

(5) One workable solution is, of course, recycling (a new word in the lexicon of the environmentalists, but long known to the mining industry). Looking back over the statistical records from 1845 to 1957, the ratio of scrap to total consumption for various metals varies, but the following are averages of recycled material: aluminum 18 percent, antimony 57 percent, copper 21 percent, gold 22 percent, iron and steel 40 percent, lead 42 percent, magnesium 14 percent, mercury 21 percent, nickel 13 percent, platinum 25 percent, silver 41 percent, tin 28 percent, and zinc 16 percent. Among the non-metals, perhaps industrial diamonds and used house bricks for architectural effects are the only commodities presently being recycled. Clearly the fuels, except for lubricating oil, cannot be re-used.

New discoveries of mineral deposits are eagerly being sought by many companies, and some deposits are being found every year, but the low ratio of success and the high cost of exploration are real deterrents. New technological advances in processing are, of course, literally creating reserves and will continue to do so.

For those who would look to the oceans for a solution, Preston Cloud of U.C.L.A. has recently written, "The 'mineral cornucopia' beneath the sea exists only in hyperbole."

JOYRIDE CAN'T LAST MUCH LONGER

The conclusion to be drawn from the data presented on our mineral reserves and their depletion might well be stated as Dr. William G. Pollard, physicist and executive director of Oak Ridge Associated Universities, puts it, ". . . our present affluent society with its phenomenal standard of living has been created by abundant resources widely and cheaply available . . . the removal of this resource base is certain to pull the rug out from under the affluent society . . . the joyride we have been on in this country can last not much more than another 20 years. After that . . . it will be simply impossible for us to continue to do simultaneously all the things we want to do."

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NEWS NOTE

The Pendleton Construction Corporation is opening a commercial quarry near Rocky Gap, Bland County, for the production of crushed stone from carbonate rocks. The company has other quarries for crushed stone in adjacent Wythe and Giles counties.

DEEP TEST — ACCOMACK COUNTY

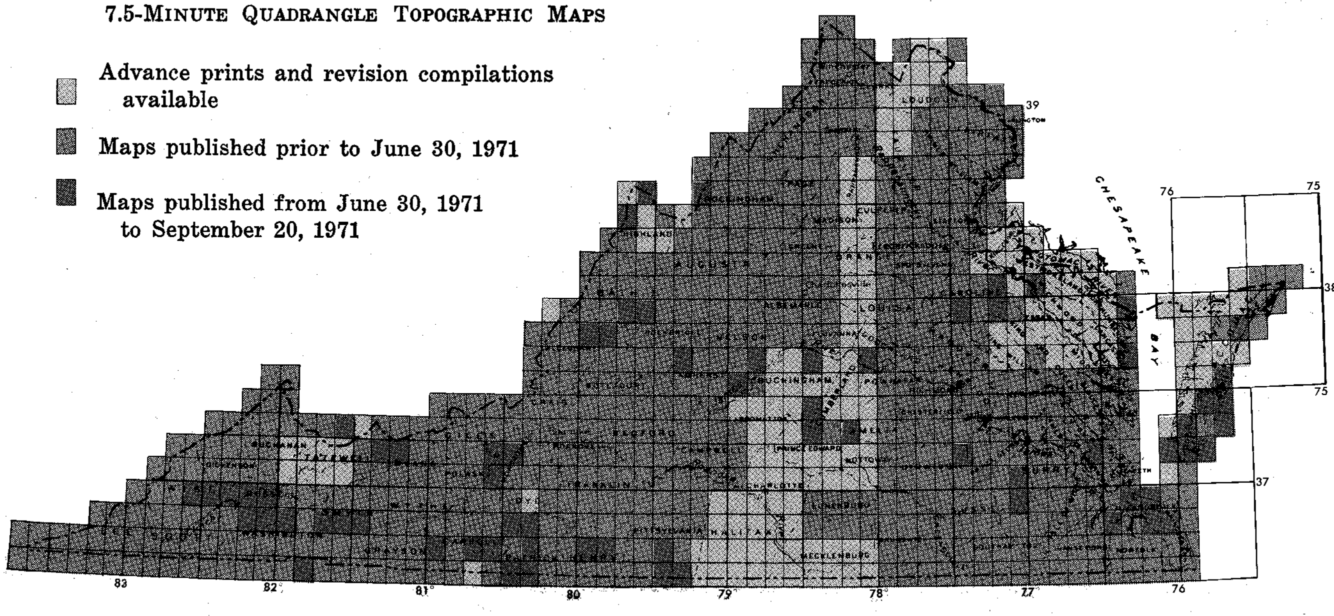
On April 9, 1971, J and J Enterprises, Inc. started drilling their E. G. Taylor No. 1-G well, 4850 feet west of longitude 78°30′W. and 3350 feet north of latitude 37°52′30″N. in northern Accomack County, about 1.75 miles north-northeast of Temperanceville, Virginia. The well was completed on May 1, 1971 at a total depth of 6272 feet. This project was a cooperative drilling venture between the U. S. Geological Survey and several petroleum companies. In conjunction with its Delmarva investigations the U. S. Geological Survey contracted to drill the first 3000 feet to obtain data on thickness and depth of aquifers and stratigraphic relationships of sediments. Various petroleum companies had the test continued to "basement" for stratigraphic and geophysical data to use in regional correlation of other rock units in the offshore area of the east coast. A set of samples are on file (W-3180) in the repository of the Virginia Division of Mineral Resources.

TOPOGRAPHIC MAPS

*Atkins
Bastian
*Blacksburg
Bloxom
*Bowers Hill
Brandywine
*Brumley
*Buena Vista
Buffalo Ridge
Burgess
*Carbo
Cartersville
Champlain
Cheriton
*Chilhowee
Claudville
Cove Creek
*Covington
*Clifton Forge
*Danville
Deatonville
Diana Mills
Elliotts Creek
Fancy Gap
Farmville
Fleets Bay
*Galax
Gary
Great Machipongo Inlet
*Hansonville
*Hayters Gap
Hightown
*Kempsville
*Laurel Bloomery
Laurel Fork
*Lebanon
*Little Creek
Manry
*Marion
*Martinsville East
*Martinsville West
Millboro
*Mt. Hermon
Nassawadox
Nimrod Hall
*Norfolk North
Petersburg
*Princess Anne
Quinby Inlet
*Radford North
*Radford South
*Ringgold
Ruther Glen
Shipman
Ship Shoal Inlet
Snowy Mountain
Sparta
*St. Paul
Stuart
Stuart SE
Supply
*Tom's Creek
Townsend
Wachapreague
Waverly
Willis
Willis Mountain
*Wise
Woolwine
*Yorktown

*Updated

7.5-MINUTE QUADRANGLE TOPOGRAPHIC MAPS



ADVANCE PRINTS AND REVISION COMPILATIONS

Advance prints and copies of revision compilations are available at 50 cents each from the U. S. Geological Survey, Topographic Division, 1109 N. Highland St., Arlington, VA 22210.

PUBLISHED MAPS

State index is available free. Updated maps, on which recent cultural changes are indicated, are now available for certain areas of industrial, residential, or commercial growth. Published maps are available at 50 cents each from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, VA 22903.

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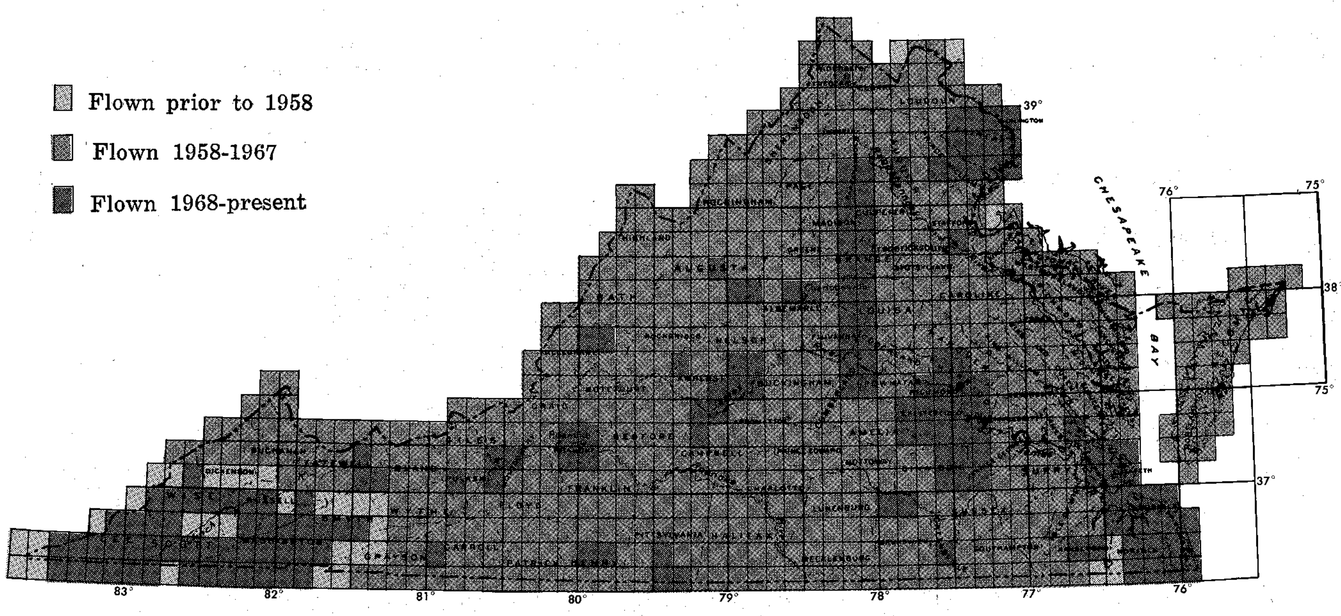

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