DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

U.S. DEPARTMENT OF INTERIOR URANIUM RESOURCE ASSESSMENT PROGRAM

by

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The following is a talk given at the Uranium Industry Information Workshop between Energy, Mines and Resources, Canada and Energy Information Administration, U.S. Department of Energy, Washington, D.C. April 11-12, 1989.

The USGS has had an ongoing uranium program for 50 years. This presentation gives you a bit of history of the program, a review of the current program, and our hopes for the future.

HISTORY OF URANIUM RESOURCE ASSESSMENT PROGRAM

Pre-1947:

Study of vanadium-uranium deposits of the Colorado Plateau began in 1939. The USGS and USBM carried out a drilling program for vanadium in 1943. A highly classified report on the uranium resources of the Colorado Plateau, prepared for the Manhattan Project concluded that there was a large uranium potential in western Colorado. This early work was done with a very low budget (1939-1946, **slide 1**). In April of 1947, a project proposal requested by the U.S. Atomic Energy Commission (AEC) was prepared to study and diamond-drill the potential areas, at first in western Colorado. The proposal predicted that one ton or more of ore would be found with each foot of drilling.

1948-1958 AEC contractural work:

Basic geologic and mine mapping, stratigraphic, structural, mineralogical, and related studies were carried out during the period. Geologic guides for ground favorable for uranium ores were developed on the basis of these and previous studies. In the peak year of 1956, the budget was about $5,500,000 for the entire Trace Elements (uranium, thorium, beryllium, other nuclear elements) program that had been expanded to cover the entire U.S. The largest single project consisted of about 125 USGS persons on the Colorado Plateau. Between 1947 and 1956, nearly 3,000,000 feet of drilling was completed on the Plateau, which was over and above the industrial drilling shown by the graph on slide 1. Mining from 1957 through 1982 from leases of the discovered ore totaled more than 3,000,000 tons. Industrial drilling peaked at a total of over 9,000,000 feet in 1957. Production increased steadily until it peaked in the 1960-61 period and decreased thereafter because of end of the AEC purchase program.

1959-1974- a core program:

During this period, the USGS maintained a core uranium program with a budget of around $1,000,000 per year. This maintained a group of about 20 USGS geologists studying and mapping uranium terranes throughout the U.S. It was this core group of experts, many with 20 or more years experience by 1974, that made possible the great expansion in 1974 to meet the energy crisis of 1973. Industry exploration showed a small peak in 1957, and after a number of years decline it peaked in 1969 at nearly 30 million feet of drilling (slide 1). Production declined to a low of a little over 10,000 tons U_3O_8 in 1966 and increased to peak on nearly 14,000 tons in 1972, after which it declined.

1974-1982 USGS and NURE programs:

In 1974, the USGS budget for uranium research increased markedly and additional funds were available from the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) program. The Survey's uranium and thorium program peaked with a combined USGS/NURE budget of nearly $11 million in 1979. During this period, exploration peaked at more than 47,000,000 feet in 1978, and the production peaked at 23,300 tons U_3O_8 in 1980.

1983-present:

The end of NURE program support and the slump in uranium demand lead to a sharply declining budget and research activities, until our present FY-89 budget of $2,093,000 (**slide 2**). The precipitous decline in budget has resulted in a fragmented uranium program and loss of uranium geologists to other programs. In addition, a large part of the uranium budget has been reprogrammed by congressional decree to fund environmental radon hazard studies. The U/Th program is being reviewed, and a revitalized, cohesive new basic and applied research effort is being planned for 1990's. We hope to maintain a second core program over the next 5 or more years until the next upswing in the uranium demand cycle.

The 1984 EIA/USGS MOU:

The termination of NURE program in 1982 and the closing of the DOE Grand Junction Operations Office in 1983, made apparent the need to transfer the responsibility of uranium resource assessment and the very large collection of NURE data to the USGS. This was done by the Memorandum of Understanding (MOU) between Energy Information Administration (EIA) of DOE and the USGS signed in 1984. The uranium resource assessment portion of the agreement called for the USGS to continue exploration research, to develop a modified NURE assessment methodology, and to carry out endowment assessments in selected areas. These new areas are to be chosen in coordination with EIA where new data have become available since the NURE assessments made in 1980, and where new discoveries of ore deposits in old and new districts would likely result in a significant (% 500 tons U_3O_8) change in the total National potential resource. The methodology and plans to update the National resource base are given in USGS Circular 994.

OVERHEAD 1

Let us now look at the present FY-89 uranium program that is being carried out in the Branch of Sedimentary Processes, Walter E. Dean Jr., Branch Chief, Denver, Colorado. The projects that are presently partly to wholly funded by the uranium program are listed with the name of the project chief. The Uranium in volcanic source rock, Plutonic rocks in NE, Regional geochemistry of uranium, and ESB/SJB projects are in their final stages. Basic uranium geology developed for plutonic rocks in the northeastern United States has been very useful in radon studies. The main efforts this fiscal year are in the Great Plains, pore water chemistry-vs-temp, Uranium resource assessment, and Surficial Uranium Deposits (SUDS). The Radon studies are largely funded by other Federal Agency funds.

OVERHEAD 2

The uranium production in 1987 was 65% from conventional mining (San Juan Basin and Grand Canyon) and 35% non-conventional mining; in-situ leach operations in Texas and Wyoming were a major part of non-conventional mining. Based on this industry activity, the initial core USGS program in the 1990 will focus on aiding industry in these main areas of production.

OVERHEAD 3

The USGS core program elements address mainly the chief sources of production and the assessment of new potential production areas. I call your attention to SUDS, Uranium endowment, Uranium province studies, Grand Canyon breccia pipes, San Juan Basin geologic mapping, and Microgeochemistry of in-situ leach ores.

The uranium province studies consist of the compilation of uranium clusters and the definition of uranium provinces based on the distribution of clusters. A cluster covers an area about 5 miles in diameter in which uranium deposits occur. The total uranium contained in ore is calculated from U.S. DOE production records and available reserve data. The Colorado Plateau Uranium Province USGS MF map report is completed and in press. The cluster compilation for the Rocky Mountain and Intermontane Basins Uranium Province is underway, and those for South Texas Gulf, Basin & Range, and Appalachian Uranium Provinces are to follow. The computer database contains various information in the GSMRDS program that will permit generation of uranium cluster maps for all or selected parts of the U.S. at different scales.

OVERHEAD 4

Surficial uranium terrane A of Washington and Idaho has been studied and estimates of undiscovered uranium endowment have been made. The mean endowment is about 35,000 tons U_3O_8; the exercise of the estimation of this endowment is given in USGS Circular 994. Surficial uranium terrane B studies in the Colorado Rocky Mountain wetlands are nearly completed, and studies in surficial uranium terrane D in New Hampshire and Maine are planned.

OVERHEAD 5

The principal studies in the San Juan Basin and Grand Canyon Region consist of geologic mapping. The San Juan Basin maps are 7.5-minute quadrangles in the areas near and downdip from presently active mines. The Grand Canyon Region maps are 1:50,000-scale quadrangles to locate and sample sites of exposed and hidden breccia pipes.

OVERHEAD 6

The study of the microgeochemistry of fine-grained sedimentary ores is to aid in-situ uranium recovery, particularly from roll-front ores in Texas and Wyoming. A pilot study of the Chadron Formation ores at Crawford, Nebraska is completed and an open-file report will be released shortly. In connection with microgeochemistry, organic geochemistry may be carried out depending upon funds and available expertise, most likely in an expanded program.

OVERHEAD 7

The Uranium Resource Assessment using the deposit-size-frequency method continues according to the plans given in USGS Circular 994. The estimates of undiscovered uranium endowment of SUDS in two 2# quads in Washington and Idaho were completed in 1986. The assessment of the solution-collapse breccia pipes in the Grand Canyon region, Arizona and adjacent Utah, was completed in 1988 for eight 2# quads. The estimates of uranium endowment revised over the 1980 NURE report were transmitted to EIA in 1988. The new estimate of the uranium endowment contained in breccia-pipe deposits is eight times greater than that reported in 1980. The Grand Canyon region has the potential of becoming the Nation's second largest source of uranium, second only to the San Juan Basin of New Mexico. In 1980, we knew of only one pipe, the Orphan Lode with large production and/or reserves (>4,000,000 lbs U_3O_8). In 1988, we knew of ten pipes with reserves and/or production of 1-7 million lbs U_30_8. In addition, major studies (>10 man-years) of breccia pipes mainly on Indian lands funded by the Bureau of Indian Affairs were completed by 1988. Our knowledge of the geology and distribution of uranium ores increased by at least an order of magnitude over the past eight years. Thus, the large increase in endowment was not surprising.

The present endowment assessment exercise is in the Chadron Formation basin which contains the roll-front deposit at Crawford, Nebraska. This deposit contains more than 30,000,000 lbs U_30_8 and is being mined by <u>in situ</u> leach methods. The original plan called for assessing the Alliance 2# quad (A1 in the slide), but mapping of the extent of the Chadron Formation has extended the assessment into 5 additional 2# quads (Scottsbluff, Torrington, New Castle, Hot Springs, Cheyenne) in Nebraska, South Dakota, and Wyoming. Because of this increase in areal coverage, the assessment will not be finished until 1990.

Future uranium assessments are planned for the Piedmont Province in the eastern United States, where the Marline deposit of >30,000,000 lbs U_30_8 occur in border faults of Triassic basins, and for SUDS terranes in California-Nevada, Colorado, and New Hampshire-Maine.

OVERHEAD 8

I will close with a word about research beyond a core program. The solution-collapse breccia pipe studies listed in this slide would be among the first to be expanded. In fact, some of topics listed in this slide may become part of the core program.

OVERHEAD 9

Studies in the metamorphic and igneous environments also would be important in an expanded program. It could be argued that perhaps the core program ought to be reoriented to deposits in these environments, limitations on available expertise and funding dictate that we focus on high-grade deposits, such as breccia pipes and sandstone deposits, located mainly in the west.

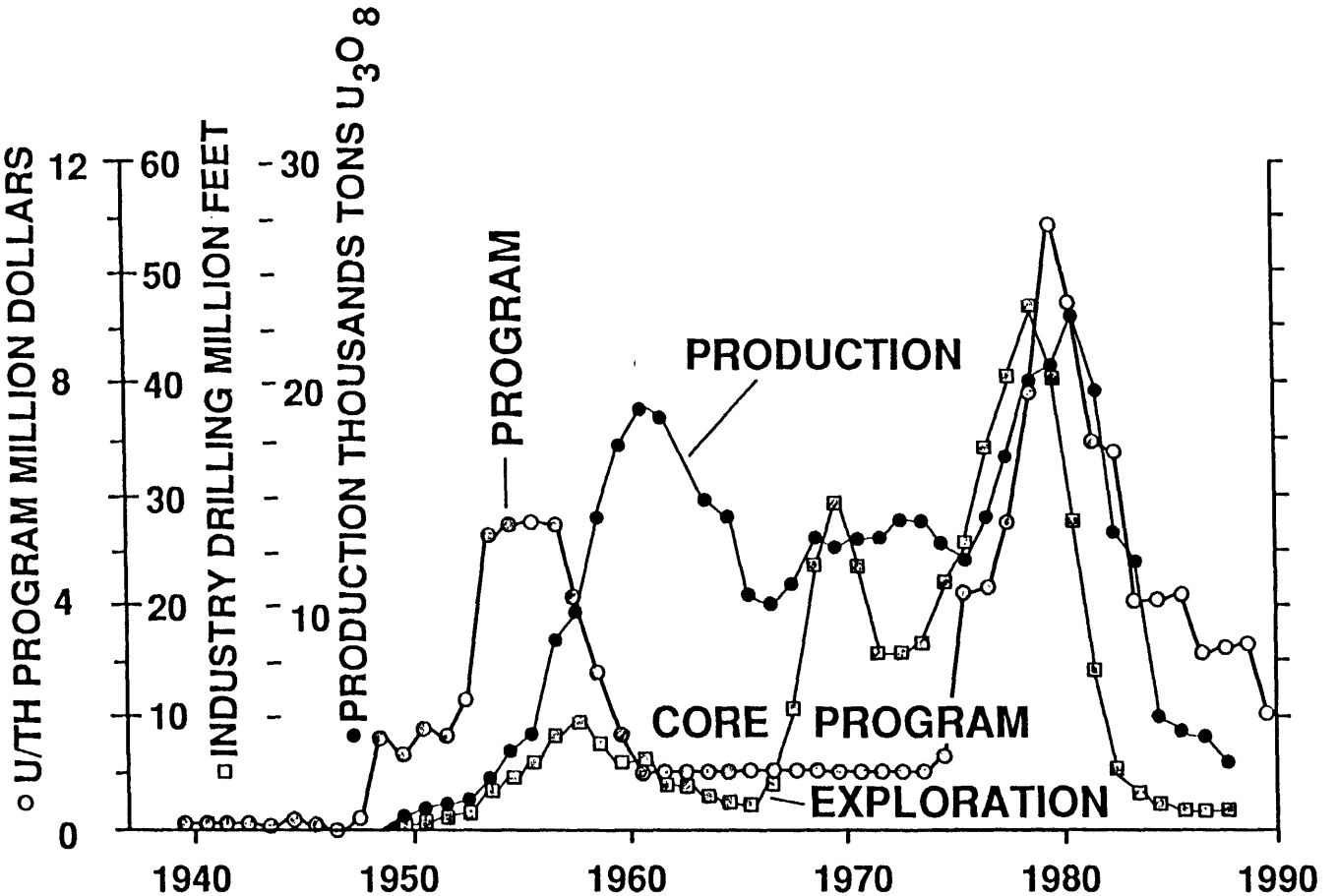
OVERHEAD 10

This slide lists a number of new research topics that could be done in an expanded program. In the Branch of Central Mineral Resources, studies are underway with a cooperative with the State of Missouri to assess the potential for Olympic Dam-type iron ores in the mid-continent of the U.S., particularly around the St. Francis Mountains. This study will also help in assessing the uranium potential of these areas.

This ends my prepared talk. I will be happy to discuss any aspects of the USGS program for basic and applied uranium research.

ACKNOWLEDGMENTS

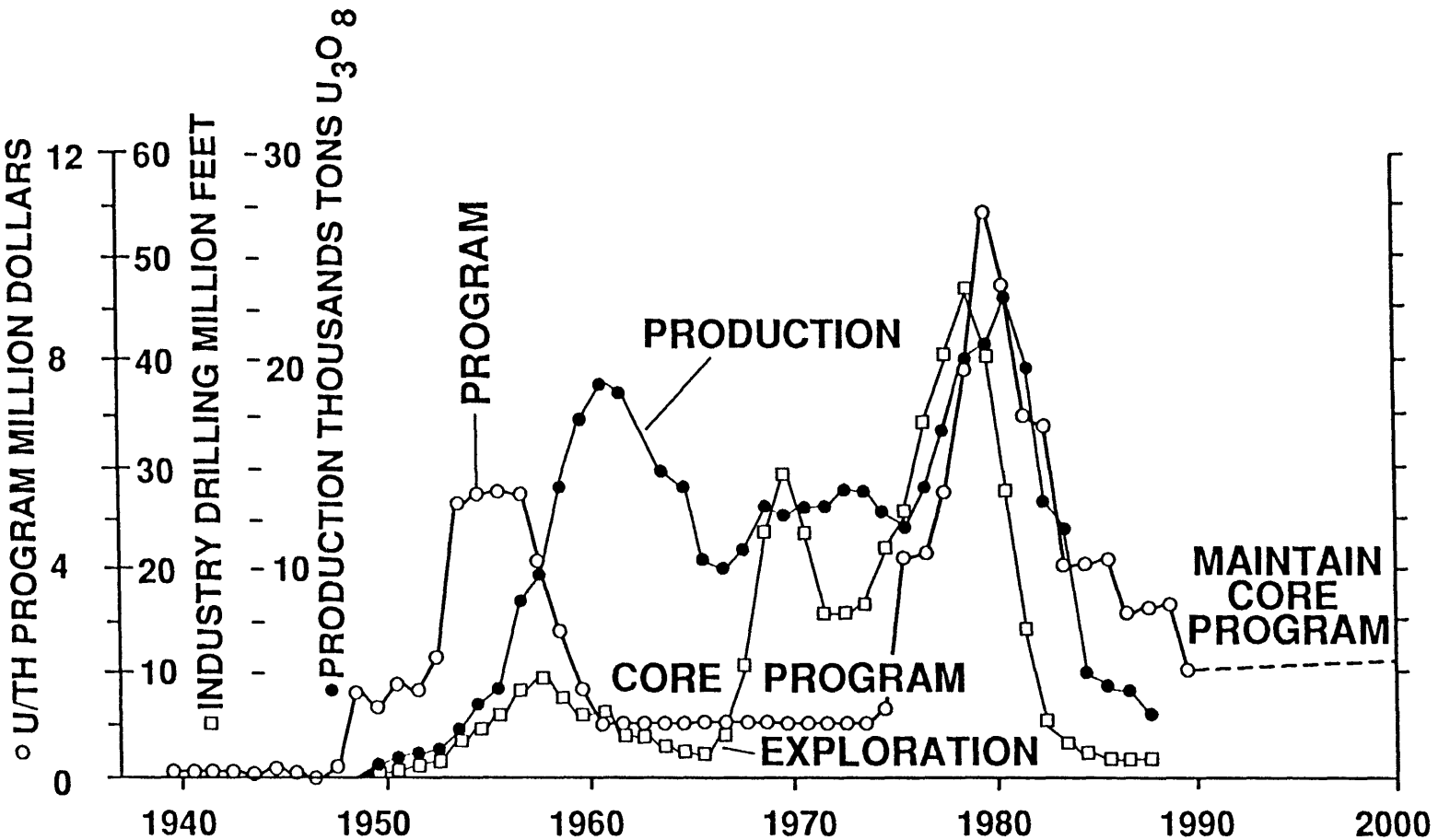
The helpful inputs to the long-range planning of the uranium research program are acknowledged, especially for contributions shown in overhead slides 5, 6, and 8-10, from the following: R.F. Dubiel, J.S. Duval, D. Frishman, M.B. Goldhaber, R.I. Grauch, P.L. Hansley, F.A. Hills, A.C. Huffman, Jr., J.T. Nash, C.J. Nutt, J.K. Otton, L.R. Page, C.T. Pierson, J.L. Ridgley, J.F. Robertston, R.F. Sanford, C.S. Spirakis, J.S. Stuckless, R.B. Wanty, K.J. Wenrich and R.A. Zielinski. R.P. Fischer is thanked for providing input on the USGS budget for pre-1947 years shown in slides 1 and 2.



U.S.G.S. U/TH PROGRAM, INDUSTRY URANIUM PRODUCTION AND EXPLORATION

Compiled by W.I. Finch, 3/89

SLIDE 1



U.S.G.S. U/TH PROGRAM,
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SLIDE 2

FY-89 RESEARCH BUDGETED BY U & TH

Uranium in volcanic source rock--**Zielinski**

Plutonic rocks in NE US--**Gundersen**

Great Plains - **Dickinson**

Uranium resource assessment--**Finch**

Regional geochemistry uranium--**Hills**

Surficial uranium deposits--**Otton**

ESB/San Juan Basin--**Ridgley**

Radon studies--**Otton**

Pore water chemistry vs temp--**Turner-Peterson**

Mobility of metals in sedimentary basins--**Breit**

Geologic process studies-radon--**Schumann**

Data systems--**Walton**

OVERHEAD 2

1987 INDUSTRY ACTIVITY

Conventional Mining - 65%

San Juan Basin - Mt. Taylor

Grand Canyon Region - Breccia -pipes

Nonconventional Mining - 35%

In-situ leaching

- Texas - roll-front
- Wyoming - roll-front

Phosphate by-product

- Florida
- Louisiana

Mine-water recovery

- New Mexico

CORE PROGRAM ELEMENTS

Radon - separate funding should be secured
SUDS - (or part of EGOR in FY-91)
    Colorado Front Range
    Piedmont province
Uranium endowment
    High Plains roll-front (NB, SD, WY)
    Appalachians (Triassic Basins border-fault province)
    SUDS (NV-CA, CO)
Uranium province studies (cluster analysis)
    Rocky Mtn - intermontane Basins
    South Texas Gulf
    Basin & Range
    Appalachians
    CPUP - grade-tonnage
Grand Canyon - breccia pipe (NEW)
    Geologic mapping (1:50,000)
Maintain presence in IAEA, NEA/OECD
San Juan Basin Geologic mapping (NEW & continuing)
Microgeochemistry of sedimentary rocks for in-situ mining extraction technology (NEW)
Model Application (ESB interface) (NEW)
    Paradox Basin
    Wyoming basins
Spatial model development (NEW)
    Westwater - SJB

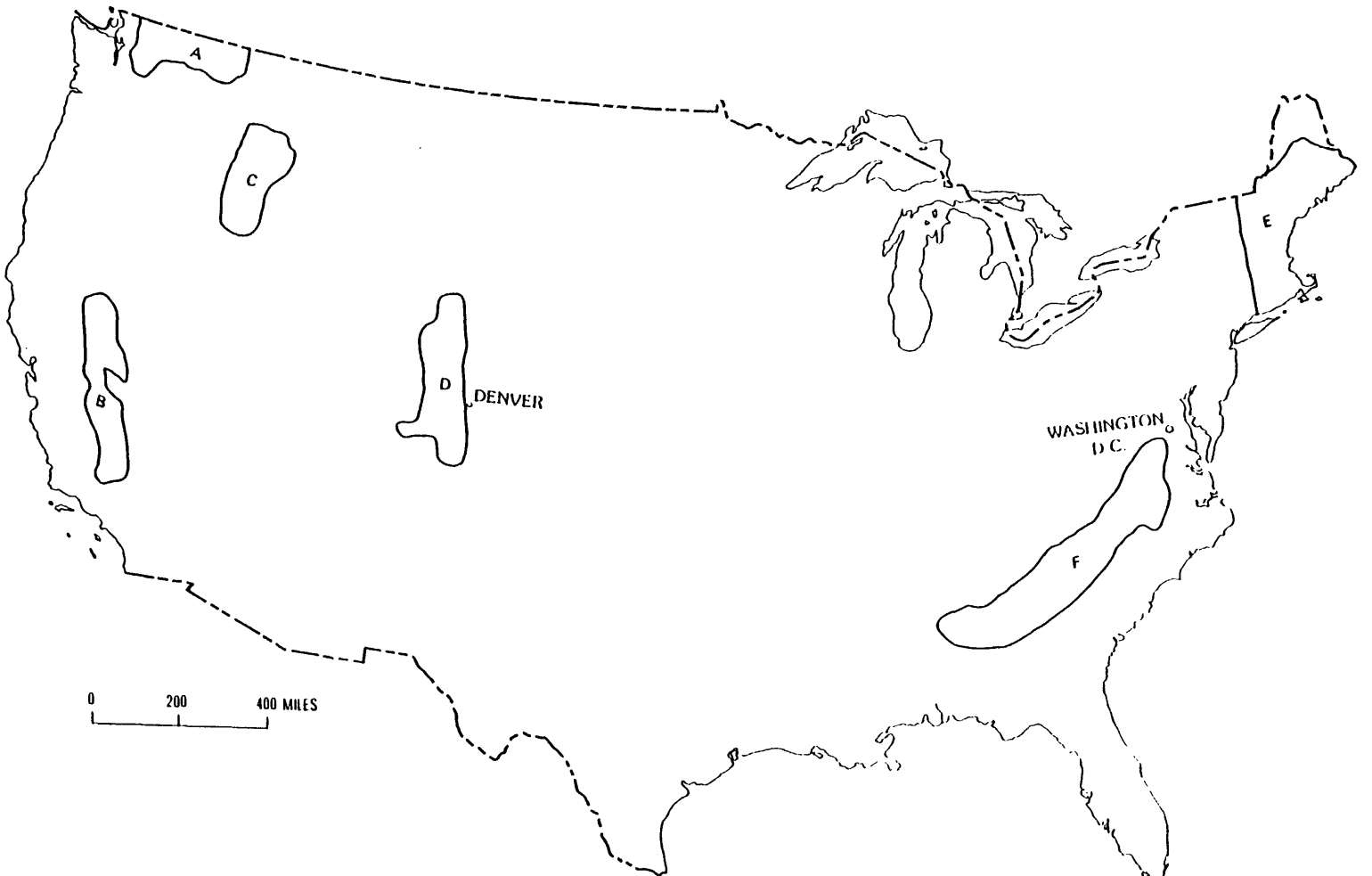

FIGURE 7.—Principal surficial uranium deposit terranes in the conterminous United States (J.K. Otton, written commun., 1985).

A. Washington-Idaho, Mesozoic-Tertiary granites
B. California-Nevada, Jurassic and Cretaceous Sierra Nevada granites
C. Idaho, Cretaceous-Tertiary granites
D. Colorado Front Range, Precambrian gneiss-granites
E. New England, Paleozoic granites
F. Piedmont physiographic province, Precambrian gneiss-granites.

GEOLOGIC MAPPING

San Juan Basin

Core program

Borrego Pass - started by Robertson
Crevass Canyon - 50% mapped by Allan Kirk

Expanded program

Mesa de los Toros - N of Ambrosia Lake
Piedra de la Aguila - NE of Ambrosia Lake
Marquez - Marquez mine area, E of Mt. Taylor volcanic field
Laguna Seca - N of Marquez
Cerro Tinaya - NE of Marquez
Herrera - W 1/2 Bernabe Montano deposit, Laguna Ind. Res.
Benavidez Ranch - E 1/2 Bernabe Montano deposit, Laguna Ind. Res.
Sky Village - NE Herrera
Canoncito - S Herrara

Grand Canyon Region

Core program

Finish Coconino Plateau* (~3,000 mi^2, 1:50,000, parts of Williams, Grand Canyon, and Flagstaff 2° quads)

Expanded program

Kaibab Plateau* (~2,000 mi^2, 1:50,000, parts of Grand Canyon and Marble Plateau 2° quads)
Kanab, Shivwits, and Sanup Plateaus* (~2,000 mi^2, 1:50,000, Grand Canyon and Cedar City 2° quads)

* Includes sampling of pipes for geochemical, mineralogic, and petrographic studies (includes industry cores)

MICROGEOCHEMISTRY OF FINE-GRAINED SEDIMENTARY ORES

(SEM, EM, X-ray, petrographic microscope)

Genesis of ores
Ore-extraction techniques for in-situ mining
Pilot study of Crawford NB ores underway
Expand to WY and TX roll-front ores
Mobile-Crownpoint, NM (possible cores & samples)
Physical and chemical properties of clay and alteration minerals in sandstone deposits

ORGANIC GEOCHEMSITRY OF FINE-GRAINED SEDMENTARY ORES

(Pyrolysis, gas-chromatography, NMR)

Role of soluable organic complexes in water-rock reactions
Synergistic clay mineral/organic reactions
Ore-extraction techniques for in-situ mining

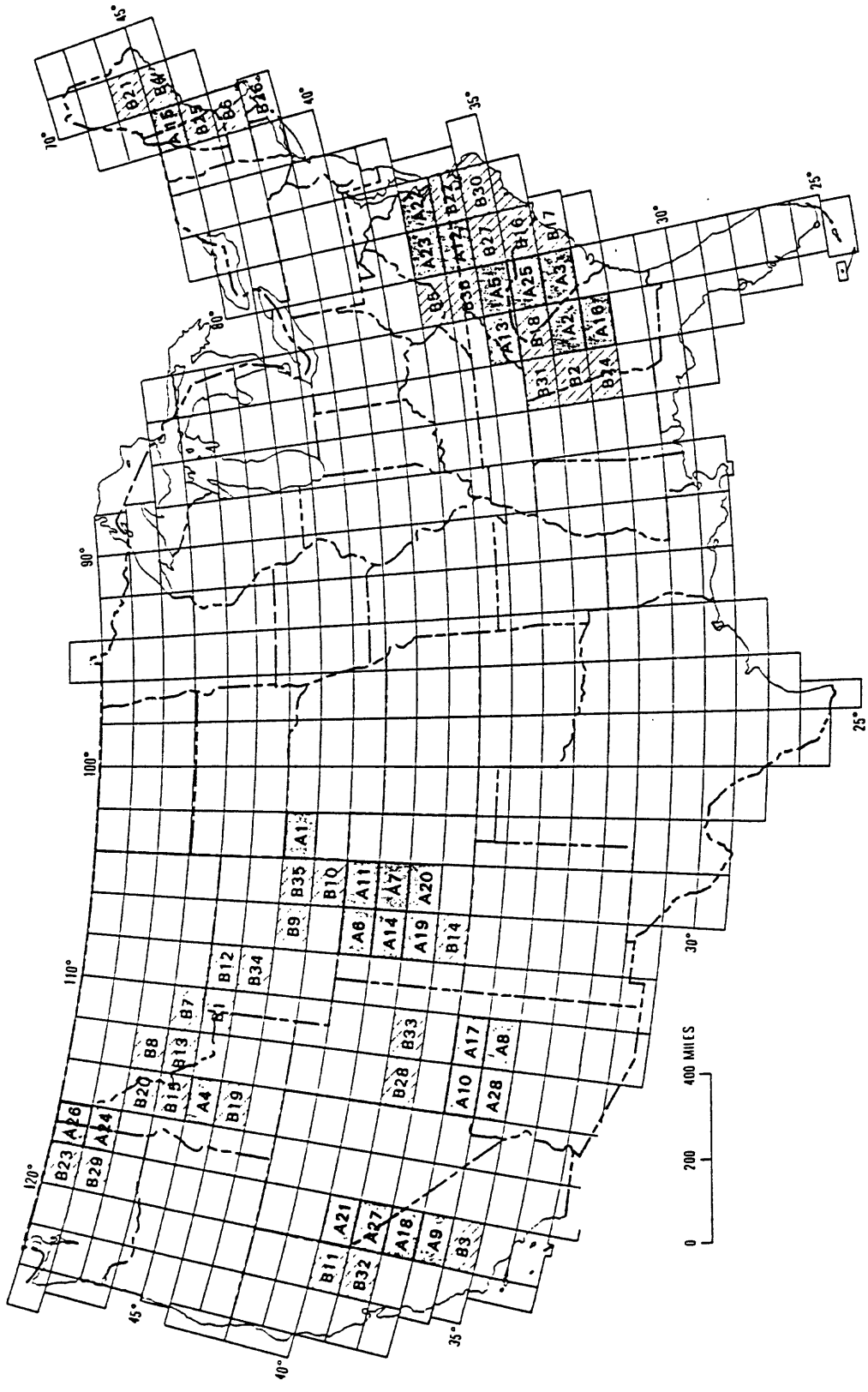

FIGURE 8.—Map of the conterminous United States showing A-priority (shaded) and B-priority (cross-hatched) NTMS 2° quadrangles for uranium endowment estimation. See table 4 for identification of quadrangles.

NEW RESEARCH

SOLUTION-COLLAPSE BRECCIA PIPE STUDIES

Density of distribution

- Variability
- Relation to fault intersections
- Map and distinguish between modern collapse and Rewall related
- Predict density beneath Late J cover rock in UT

Mineralogic and geochemical signatures

- Ore-bearing relative to barren
- Relation to nearby Chinle ores
- Relation to other collapses - Temple Mtn, Woodrow
- Relation to sandstone ores in Permo-Penn rocks to south

Source of uranium

- Hydrology and direction of fluid movement
- Geochemistry of U-bearing, S-bearing fluids
- Evidence for mixing U- & S-bearing fluids

Thermoluminescence application to breccia pipes

OVERHEAD 9

NEW RESEARCH

HIGH-GRADE VEIN ENVIRONMENTS IN FRONT RANGE, COLORADO

Water and gas geochemistry to identify targets
Thermoluminescence application

URANIUM GEOCHEMISTRY DURING MAGMATIC STAGES OF IGNEOUS PROCESSES

Uranium partitioning coefficients
Uranium segregation:
- Late stage pegmatite
- Labile state
- Refractory minerals

UNCONFORMITY-VEIN TYPE URANIUM DEPOSITS

Assess state-of-art model from Canadian, Australian, and French research
Formulate new research plan, especially on regolith and regional geology to identify favorable unconformities

EASTERN U.S.

Metamorphosed submarine volcanic exhaltives in Precambrian rocks
Triassic basin border-fault environments
Develop prospecting techniques in humid-temperate climate with deep weathering and in glacial terrane
SUDS

NEW RESEARCH

REGIONAL SIGNATURES FOR URANIUM PROVINCES

- GIS - NURE aerogamma-ray data, other existing data
- Remote sensing
  - Satellite
  - Gamma-ray
  - High-sensitivity magnetic data
  - Variable-frequency electromagnetic
- Data presentation technology
  - Enhance subtle anomalies

PALEOHYDROLOGY OF URANIUM TRANSPORT AND DEPOSITION

- Colorado Plateau - SUB

STRATIGRAPHIC STUDIES

- Jurassic - Salt Wash in Paradox Basin
- Triassic - Colorado Plateau, Southern High Plains

MID-CONTINENT OLYMPIC DAM POTENTIAL

MICROBIOLOGY

- Innovative, creative biogeochemistry

SUDS

- Uranium geochemistry in soils and parent rocks
- High Plains uranium potential
- Basin and Range potential
- Microgeochemistry of SUDS ore to aid metallurgy as well as environmental problems