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Uranium and Thorium Resource Assessment

and

Exploration Research Program,

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By

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards.

INTRODUCTION

After expansion of the USGS (U.S. Geological Survey) uranium-thorium program in FY (fiscal year) 1975, new directions of research could be pursued, particularly in sedimentology or genetic stratigraphy, geochemistry-mineralogy, and geophysics. In a relatively short time, many of the new research projects have developed critical information on uranium habitats and improved methods of exploration. In FY 1979 a budget increase of approximately 20 percent is programmed, for a funding base of $6,600,000. The increase is scheduled for research grants and contracts outside the USGS in order to extend the basic program without additional personnel. This outside research will be designed not only to increase basic information on uranium occurrence but also to aid the USGS in its evaluation of uranium favorability in key resource areas for the NURE (Natonal Uranium Resource Evaluation) program of of DOE (U.S. Department of Energy).

OBJECTIVES AND PROGRAM SCOPE

The USGS program is designed to improve our understanding of the nature and distribution of uranium and thorium resources of the United States. In studies of known uranium areas we are applying modern concepts of stratigraphy, sedimentation, and igneous and metamorphic petrology, together with modern geochemical and geophysical methods, to obtain new insights into uranium habitat. From these we hope to develop better geologic guides and exploration methods to aid industry in its vital economic role. As basic

understanding is improved, we are expanding our work as rapidly as possible to cover frontier provinces of the United States, seeking hitherto unrecognized analogs of known uranium habitats. In particular, increasing attention is being given to investigations of non-sandstone occurrences and promising environments. A major goal throughout the program is to build models of uranium or thorium occurrences which can be used together with area geologic information to improve favorability estimates and resource appraisal for any given potential uranium or thorium habitat.

Program activities are defined in six scientific-discipline coordination areas, or program elements. These, and appropriate percentages of USGS base funding in each, are:

1. Uranium geochemistry and mineralogy----------35
2. Uranium in sedimentary environments----------28
3. Uranium in igneous and metamorphic environments-------10
4. Uranium geophysics----------20
5. Uranium resource assessment---------- 5
6. Thorium investigations and assessment---------- 2

Research in non-sandstone environments shows an apparent decrease relative to FY 1978 because personnel have been assigned to similar DOE-sponsored studies.

As reported last year, studies of known uranium areas are increasingly being approached by scientific teams or task forces involving personnel of several program elements. New looks at major districts studied and reported on long ago are yielding much detail not previously recognized and greatly improving the understanding of

uranium mineralization. Much more work is needed as modern approaches and tools are applied, but over the next 2-3 years such district studies will result in many individual topical reports enroute to a major synthesis of uranium occurrence and origin for each area studied.

Program personnel include 56 geoscientists and 28 technical or clerical personnel full or part-time in the Branch of Uranium and Thorium Resources, as well as 38 scientists and 18 support personnel full or part-time in the Branches of Petrophysics and Remote Sensing, Electromagnetics and Geomagnetism, Experimental Geochemistry and Mineralogy, Isotope Geology, Eastern Mineral Resources, Central Mineral Resources, Western Mineral Resources, Eastern Environmental Geology, Western Environmental Geology, Alaskan Geology, Paleontology and Stratigraphy, and Chemical Resources. Approximately 70 man years of professional time will be devoted to the program by USGS personnel in FY 1979. The program includes 66 active research projects.

Continuing Program Activities

Most projects from the previous year are continuing and a few new ones are being started in FY 1979. Project objectives and current plans are listed below, by program element.

Uranium Geochemistry and Mineralogy:

This element encompasses research on the theory of origin of deposits and on geochemical techniques. Work in these directions is done in close coordination with field mapping and geophysics projects. The coordinator is Joel S. Leventhal.

1. Uranium ore-forming processes (H. C. Granger)--Objective: To

investigate geochemical processes of uranium concentration in low-temperature deposits, particularly relations among U, S, Se, dissolved O_2, and humic matter. Plans: Develop a geochemical model for genesis of Colorado Plateau-type deposits; complete a computer model study of roll-front deposit shapes.

2. Geochronology of uranium ores and their host rocks (K. R. Ludwig)--Objective: To determine of ages of uranium ores in vein and sandstone deposits, chiefly by Pb-U method. Plans: Study of ores from Marysvale, Henry Mountains, and Thomas Range, Utah; Powder River Basin, Wyoming; and Pitch mine, Colorado.

3. Organic geochemistry of uranium (J. S. Leventhal)--Objective: To determine chemical nature of organic matter associated with uranium and its role in ore genesis or concentration. Plans: Detailed study of organic matter from deposits in Wyoming, New Mexico, Utah; contribution to genetic modeling of sandstone-type uranium deposits.

4. Granite source-rock studies (J. S. Stuckless)--Objective: To investigate granites as sources of uranium in adjacent sandstone-type deposits and in intragranite vein deposits. Plans: Continued isotopic studies to document granite-body histories and the extent of uranium preconcentration and subsequent mobility.

5. Uranium and trace elements in Devonian black shale (J. S. Leventhal, M. B. Goldhaber)--Objective: To establish relation of uranium and other trace elements to organic matter and sulfides in the Chattanooga Shale, Kentucky and West Virginia. Plans: Continued study to define regional vertical and horizontal distribution of

anomalous uranium values in the shale.

6. Volcanic source-rock studies (R. A. Zielinski)--Objective: To investigate the derivation of uranium in sandstone ores from volcanic rocks or volcanic components in sediments. Plans: Experimental leaching of uranium from altered volcanic glass; analysis of a water-laid tuff, Keg Mountains, Utah, to define uranium sites and mobility.

7. Relation of diagenesis to uranium deposits (M. B. Goldhaber)--Objective: To establish the relation of diagenetic processes and their geochemical effects to uranium concentration and mobility. Plans: Laboratory study of bacterial oxidation of pyrite and reduction of uranyl ion by H_2S and various sulfur-oxide species; mineralogic and isotopic study of orebodies in Wyoming, Texas, and Utah.

8. Paleomagnetism applied to uranium exploration (R. L. Reynolds)--Objective: To identify magnetic-mineral phases associated with sandstone uranium concentrations and related alteration, as a means of elucidating ore-forming processes and deposit histories. Plans: Study of magnetic properties, petrography (including microprobe), and geochemistry of uranium deposits in Wyoming, Texas, and Utah, to identify the mineralogic residence of uranium and characterize authigenic mineral phases related to mineralizing processes.

9. Stable isotopes and uranium-ore genesis (R. O. Rye)--Objective: To study D/H, O^{18}/O^{16}, S^{34}/S^{32}, C^{13}/C^{12}, and CO_2 as indicators of geochemical process in, and origin of, uranium

deposits. Plans: Continued study of sandstone-type deposits in Texas, Wyoming, Utah, and New Mexico.

10. Geochemical techniques in uranium exploration (R. A. Cadigan)--Objective: To compile and analyze regional geochemical data. Plan: Study of data on uranium, helium, and radon in Colorado and of geochemical data for Colorado Plateau.

11. Uranium daughter products in modern decaying plant remains and in soils and stream sediments (K. J. Wenrich-Verbeek)--Objective: To determine extent of absorption of uranium on decaying plant material and on different size fractions of stream sediments, and climatic-zone differences in this. Plans: Comparison of sample data from eastern and western states.

12. Geochemical-halo uranium exploration techniques (C. S. Spirakis)--Objective: To identify and interpret possible geochemical/mineralogic halos around orebodies in order to elucidate chemical processes of ore formation and establish larger targets for exploration. Plans: Expanded study of thermoluminescence in quartz around roll-front deposits; study of samples from New Mexico deposit.

13. Radium and other isotopic-disintegration trace-element migration in springs and subsurface water (J. K. Felmlee)--Objective: To study natural radioactive waters as possible indicators of subsurface uranium deposits. Plans: Reporting on Colorado studies and sampling of California mineral springs.

14. Uranium in streams as an exploration technique (K. J. Wenrich-Verbeek)--Objective: To evaluate and apply methods of surface-water sampling and geochemistry as a means of uranium

exploration. Plans: Publication of reports to complete project.

15. Gaseous-emanation detection techniques for uranium exploration (G. M. Reimer)--Objective: To develop equipment and field measurement techniques to evaluate helium, radon, and other gaes as indicators of buried uranium deposits. Plans: Continued testing of helium in soil gas and water for exploration applications.

In addition, studies are underway in the Branch of Experimental Geochemistry and Mineralogy on thermodynamic data for uranium minerals; electron petrography of black uranium ores; and the aqueous system U-Se-S-O-H under sedimentary-deposit conditions.

Uranium in Sedimentary Environments

This research area involves sedimentology, stratigraphy, study of subsurface data, detailed investigation of ore deposits, and regional and local study of basin environments and sandstone districts. The coordinator is M. W. Green.

1. Stratigraphic and sedimentary environment studies, San Juan Basin uranium, New Mexico (M. W. Green)--Objective: To apply modern stratigraphic techniques to stratigraphic correlations within the Morrison and related formations as guides for exploration. Plans: Detailed study of subsurface data and definition of depositional environment patterns.

2. Stratigraphic analysis of Tertiary uranium basins of Wyoming (D. A. Seeland)--Objective: To develop uranium-occurrence model based on sedimentary environment and fluvial patterns. Plans: Continued study of Eocene basin environments of deposition; Green River Basin paleodrainage model.

3. Stratigraphic analysis of the Western interior Cretaceous uranium basins (H. W. Dodge, Jr.)--Objective: To study depositional environments in relation to uranium favorability. Plans: Continued study of Lance-Fox Hills environments, eastern Powder River Basin, and of the Eagle Sandstone in north-central Montana.

4. Textural auto-image-analyzer (M. B. Sawyer)--Objective: To develop automated techniques for measuring or analyzing rock-texture parameters, sediment character, and fission tracks. Plans: Comparison of results of automated measurement with sieve analysis.

5. Basin analysis as related to uranium potential of Triassic sedimentary rocks in the eastern United States (C. E. Turner-Peterson)--Objective: To define sedimentary environments and their influence on uranium. Plans: Report to complete study of the Newark and Gettysburg Basins.

6. Basin analysis as related to uranium potential in Permian rocks of the Colorado Plateau and midcontinent region (J. A. Campbell)--Objective: To define areas of uranium potential and controls on mineralization through depositional-environment and stratigraphic studies. Plans: Compilation of data on Cutler Formation in the Paradox Basin area.

7. Sedimentology of Ambrosia Lake uranium district, San Juan Basin, New Mexico (C. E. Turner-Peterson)--Objective: To elucidate sedimentational influence on ore deposition through detailed surface, subsurface, and mine studies. Plans: Test of lacustrine-facies model.

8. Uranium geology and potential resources of the Tertiary of

the Great Plains (K. A. Dickinson)--Objective: To define areas favorable for uranium mineralization on the basis of stratigraphy and depositional environment. Plans: Begin study of the Denver Basin, including radiometric and geochemical sampling of soils and weathering profiles.

9. Basin analysis of uranium-bearing Jurassic rocks of the Colorado Plateau (F. Peterson)--Objective: To re-evaluate stratigraphy and uranium occurrence in terms of depositional-environment factors. Plans: Further development of Salt Wash Member (Morrison Formation) depositional model; multidiscipline approach to studies of Henry Mountains and Uravan districts; study of Colorado Plateau Jurassic-Cretaceous boundary.

10. Basin analysis of uranium-bearing Triassic sedimentary rocks of the Colorado Plateau (R. D. Lupe)--Objective: To re-evaluate stratigraphy and uranium occurrence in terms of depositional-environment factors. Plans: Continued regional surface and subsurface study, extending from past work in Utah and Arizona into New Mexico.

11. Uranium deposits of Wyoming (F. C. Armstrong)--Objective: To study the Gas Hills District Plans: Report to complete project.

12. Uranium studies in western Arizona Tertiary basins (J. K. Otton)--Objective: To define the geologic setting of uranium mineralization in the Date Creek and similar basins. Plans: Continued mapping and subsurface stratigraphic synthesis in Date Creek Basin; reconnaissance of adjacent basins.

13. Middle and late Tertiary history of parts of northern Rocky

Mountains and Great Plains uranium regions (N. M. Denson)--Objective: To define Tertiary history of source areas and adjacent basins. Plans: Continued study of depositional history of Tertiary sediments in Powder River Basin as related to different source-area uplifts.

14. Stratigraphic and geochemical studies of uranium host strata, Powder River Basin, Wyoming (E. S. Santos)--Objective: To determine physical and chemical relations of ores and host rocks. Plans: Report preparation; mineralogic study of ores and host rocks.

15. Badwater Creek-Copper Mountain uranium area, Wyoming (R. E. Thaden)--Objective: To map the area geologically and define those aspects related to uranium occurrence. Plans: Publication of Birdseye Pass, Picard Ranch, and Gates Butte quadrangle geologic maps.

16. Sanostee uranium studies, New Mexico (A. C. Huffman, Jr.)--Objective: To provide a framework for uranium studies and exploration through quadrangle geologic mapping. Plans: Study of uranium occurrences in project area.

17. Window Rock uranium studies, New Mexico-Arizona (R. E. Thaden)--Objective: To provide a framework for uranium studies and exploration through quadrangle geologic mapping. Plans: Completion of Sonsela Buttes 4 SE quadrangle geologic mapping; publication of geologic map of Crystal quadrangle.

18. North Church Rock uranium, New Mexico (A. R. Kirk)--Objective: To provide a framework for uranium-occurrence modeling and exploration through geologic mapping and subsurface and mine studies. Plans: Completion of mapping; publication of subsurface-

correlation, structure-contour, and isopach maps of Dakota Sandstone and members of Morrison Formation; lineament and fracture study of the Gallup-Grants area.

19. Chama Basin, New Mexico-Colorado (J. A. Ridgley)--Objective: To map the area geologically, and develop exploration guides. Plans: Publication of geologic map of Arroyo del Agua quadrangle; continued study of Morrison stratigraphy and uranium potential of the Burro Canyon Formation.

20. Crownpoint uranium, New Mexico (J. F. Robertson)--Objective: To map the area geologically, relating uranium occurrences to stratigraphy. Plans: Continued study of mines in the Smith Lake-Mariano Lake trend.

21. Uranium potential of Lower Cretaceous rocks of the Uinta and Piceance Basins, Utah-Colorado (L. C. Craig)--Objective: To define depositional environments and their relation to uranium occurrence. Plans: Study of uranium occurrences; revision of report on the Burro Canyon Formation.

22. Uranium potential of Tertiary sedimentary rocks in Alaska (K. A. Dickinson)--Objective: To study sedimentary environments in selected basins. Plans: Publication of data on uranium sampling in interior Tertiary basins.

23. Uranium potential of the southern high plains (W. I. Finch)--Objective: To define habits of uranium occurrence in Triassic, Jurassic, and younger rocks in determining guides for exploration. Plans: Completion of reports on the Santa Rosa Sandstone and tabulation of characteristics of uranium deposits in

west Texas and eastern New Mexico.

Uranium in Igneous and Metamorphic Environments:

1. Midnite mine uranium area, Washington (J. T. Nash)--Objective: To definite geologic setting, mineralogy, geochemistry, and genesis of the uranium deposits. Plans: Report on geochemistry and mineralogy of granitic rocks of the region and their favorability for uranium.

2. Uranium potential of vein-disseminated deposits in western United States (J. T. Nash)--Objective: To develop geologic guides to new deposits and document mechanisms of uranium concentration. Plans: Study of mineralogy, petrology, and chemistry of Pitch mine, Colorado, ore and host rocks; fission-track dating of Front Range veins.

3. Uranium potential of the Basin and Range province (C. S. Bromfield)--Objective: To establish uranium-favorable environments by reconnaissance methods and selected detailed study, particularly of volcanic and basin-fill rocks. Plans: Continued study of silicic volcanic rocks in Lakeview, Oregon, district; examination of uranium occurrences in Tertiary sediments in the White Hills and Muggins Mountains and in rhyolites in the Big Lue Mountains, Arizona.

4. Uranium veins in eastern United States (R. I. Grauch)--Objective: To determine favorable environments and genesis of uranium occurrences. Plans: Detailed study of occurrences in the Reading Prong.

5. Marshall Pass uranium-thorium studies, Colorado (J. C. Olson)--Objective: To determine the geologic setting and controls of

mineralization. Plans: Preparation of final map and report.

6. Uranium potential of plutonic rocks of the northeast United States (E. L. Boudette)--Objective: To evaluate potential for vein, disseminated, and contact-metamorphic uranium deposits. Plans: Continued study of petrology, geochemistry, and uranium of 2-mica granites.

7. Uranium investigations in metamorphic rocks of the Great Lakes region (M. R. Brock)--Objective: To definite uranium-rich Precambrian rocks or favorable environments analogous to those of foreign unconformity-vein, granite, and quartz-pebble conglomerate deposits. Plans: Study of high-uranium quartzites and granites, and of mid-Precambrian unconformity.

8. Western Alaska uranium studies (T. P. Miller)--Objective: To investigate potential for uranium-thorium deposits in plutonic rocks of the Seward Range and their eastward extension. Plans: Definition of petrologic character of granites and study of recently found high-uranium localities.

9. Uranium potential in Precambrian sedimentary and metasedimentary rocks (F. A. Hills)--Objective: To define, by isotopic and other methods, Precambrian basin environments suitable for quartz-pebble conglomerate deposits. Plans: Study of conglomerate areas in Wyoming, South Dakota, and Idaho; investigation of genesis of uranium deposits in Dripping Spring Quartzite, Arizona.

Geophysical Techniques in Uranium and Thorium Exploration:

This research is conducted in the Branches of Petrophysics and Remote Sensing, Electromagnetics and Geomagnetism, and Isotope

Geology. The coordinator is J. H. Scott.

1. Remote sensing for uranium exploration (G. L. Raines)--Objective: To refine remote-sensing techniques for recognition of geologic features (structure, facies, and alteration) associated with uranium mineralization. Plans: Analysis of aerial multichannel spectrometer data for Powder River Basin uranium areas; spectral-reflectance and lineament mapping of San Juan Basin and Colorado Plateau.

2. Gamma-ray spectrometry in uranium exploration (J. S. Duval)--Objective: To refine existing aerial survey tools and techniques and develop interpretive methods. Plans: Continued development and application of color-composite presentation of spectral radiometric data; analysis of plastic-scintillator aerial survey data.

3. Mineral exploration by gamma-ray spectrometry in crystalline rocks (J. A. Pitkin)--Objective: To test truckborne spectrometer for exploration in areas unsuited to aerial surveys. Plans: Continued surveys in Front Range and other Colorado areas.

4. Geophysical studies relating to uranium deposits in crystalline terranes (D. L. Campbell)--Objective: To test and refine nonradiometric geophysical methods for exploration and study of uranium localities. Plans: Completion of study of Camp Smith mine, New York; continued surveys and geophysical analysis, Pitch mine, Colorado.

5. Uranium geophysics in frontier areas (J. W. Cady)--Objective: To test the use of geophysical data on regional and local scale to establish environments favorable for uranium. Plans:

Continued study of regional data for northeast Washington.

6. Borehole geophysical research in uranium exploration (J. H. Scott)--Objective: To develop borehole geophysical data acquisition and computer interpretation techniques for detecting uranium deposits. Plans: Continued development of tools and techniques in surveys of deposits in Wyoming and Utah.

7. Borehole electrical techniques in uranium exploration (J. J. Daniels)--Objective: To develop hole-to-hole and hole-to-surface measurement techniques and interpretation methods. Plans: Continued testing of approach in surveys of uranium deposits in Wyoming and Utah.

8. Surface electromagnetics in uranium exploration (B. D. Smith)--Objective: To apply and evaluate IP (induced polarization) and other non-radiometric geophysical methods for detection of uranium deposits or favorable geologic environments. Plans: Laboratory and field measurements of ore and rock electrical properties; reporting on survey results for Weld County, Colorado, and southeast Utah.

9. Uranium petrophysics (G. R. Olhoeft)--Objective: To establish basic data on physical and electrical properties of ore and surrounding rocks. Plans: Correlation of laboratory and field measurements; continued study of nonlinear electrical properties of ore materials.

10. Uranium disequilibrium studies (F. E. Senftle)--Objective: To develop a downhole probe for direct high-sensitivity assays of uranium and thorium and measurement of disequilibrium. Plans:

Production of probe for routine field surveys; development of analog-to-digital direct readout of probe data during surveys.

Uranium Resource Assessment Group:

This group, headed by W. I. Finch and working with the U.S. Geological Survey Office of Resource Analysis, is carrying out research on methods of resource assessment. The approach involves the development of geologic-genetic models emphasizing extensive lists of geologic parameters associated with particular kinds of deposits or their habitats and indicative of processes of ore deposition and origin. Field data on geologic factors and uranium occurrences are to be analyzed by computer in terms of the appropriate models, using techniques such as characteristic analysis. Regional data sets are to be compiled for favorability pattern recognition analysis. The San Juan Basin will be the initial test area.

Thorium Investigations and Resource Assessment:

This effort expanded in FY 1977 to cover increased responsibilities in behalf of the NURE program. Phase I, an inventory of the major and best known resource areas, was completed in May 1978. Scientific investigations of Phase II will extend through FY 1980, with assessment of resources in lesser deposits being reported on in April 1979. The thorium research is coordinated by M. H. Staatz.

1. Thorium resource investigations (M. H. Staatz)--Objective: To assess resources in eastern U.S. and Idaho placers and other deposits of potential economic interest. Plans: Completion of NURE

thorium Phase II resource assessment report; expansion of studies of potentially mineralized alkalic rocks.

2. Thorium investigations in igneous rocks (M. H. Staatz)--Objective: To study geologic setting and size, shape, mineralogy, and geochemistry of significant thorium occurrences in detail. Plans: Continued study of disseminated deposits in Bear Lodge Mountains, Wyoming, and of veins at Laughlin Peak, New Mexico.

3. Cochetopa uranium-thorium deposits, Colorado (J. C. Olson)--Objective: To perform detailed geologic mapping and other studies to establish setting and resource potential of deposits. Plan: Report and geologic map to complete the project.

4. Thorium resource appraisal of the Wet Mountains district (T. J. Armbrustmacher)--Objective: To study known thorium-rich veins in detail. Plan: Continued petrologic, isotopic, and geophysical studies of alkalic rocks and thorium veins.

5. Appraisal of thorium beach-placer deposits, southeastern United States (E. R. Force)--Objective: To study the geology and thorium potential of heavy-mineral placer occurrences. Plans: Continued work in Coastal Plain areas.

Research Grants and Contracts Presently Allocated for FY 1979

1. Field and laboratory study of rocks within anomalous areas identified in DOE radiometric surveys of the Reading Prong (Pennsylvania Geological Survey).

2. Laboratory study of clays with respect to uranium geochemistry (Pennsylvania State University).

3. Study of uranium in zircons and other heavy minerals in the

Morrison Formation and its source rocks, San Juan Basin (California Institute of Technology).

4. Experimental study of channel formation in varying flow conditions, and relation to sedimentation favorable for uranium (Colorado State University).

5. Study of metamorphic rocks relatively favorable for uranium mineralization in the southeastern Piedmont (Alabama and Georgia Geological Surveys).

6. Development and testing of borehole technique for direct measurement of uranium (Colorado School of Mines).

7. Study of thorium-rich placer accumulations, Georgia Coastal Plain (Georgia Geological Survey).

SELECTED NOTEWORTHY RESULTS OF FY 1978 RESEARCH

*NURE thorium Phase I appraisal resulted in resource estimates in the major vein districts and disseminated deposits considerably larger and more economic than had been expected (M. H. Staatz).

*Roll front deposits in Wyoming were found to have relatively coarse-grained uraninite associated with vanadium and selenium, in contrast with roll-front deposits of south Texas that contain fine-grained uraninite associated with clay- and titanium-mineral phases produced by alteration (the titanium species involving sulfidization of oxide minerals). The differences suggest different uranium fixation processes, solution chemistry, and effects of host-rock composition (R. L. Reynolds).

*Sulfide minerals and sulfur isotopes distinguish rereduced ground behind a Texas roll-front deposit and indicate that the

deposit is unrelated to modern H_2S and ground water (M. B. Goldhaber).

*Analysis of drill core from fractured granite shows that as much as 20 percent of uranium in the granite is leached and introduced into the drilling mud during drilling, and so core assays do not provide an accurate measure of uranium content of undisturbed rock (J. S. Stuckless).

*Organic matter in plateau-type deposits is degraded to resemble amorphous carbon; it not only concentrated uranium but also then served to protect it from remobilization. In Chattanooga Shale, U, Mo, and V are directly correlated with organic matter, preferentially of land rather than marine origin (J. S. Leventhal).

*Five localities of radioactive quartz-pebble conglomerate were found in the Sierra Madre Mountains, Wyoming in a study sponsored by the USGS and DOE (University of Wyoming).

*Study of uranium in the Permian Cutler Formation shows it to differ petrographically, chemically, and mineralogically from uranium in the Triassic Chinle Formation or Jurassic Salt Wash Member (Morrison Formation) host rocks (J. A. Campbell).

*Uranium deposits in Date Creek Basin, Arizona appear to be entirely of early to middle Miocene age, associated with silicification within tuffaceous sediments deposited in a lacustrine environment (J. K. Otton).

*Studies of the Triassic Chinle have permitted its subdivision into depositional packages that can be related to uranium occurrence and a paleogeographic reconstruction that links Chinle-age rocks

across Nevada and Utah (R. D. Lupe).

*Surface IP surveys in a Utah area of uranium-bearing channels 60 m deep show small but persistent anomalies corresponding to zones of mineralization and hole-to-hole geophysical anomalies. The IP anomalies come from features 10-15 m above the ore, suggesting a mineralogic/geochemical halo (B. D. Smith).

*In the Great Lakes area, two new uranium-bearing phosphatic units and an area of anomalously radioactive quartzites were found (M. R. Brock).

*Two occurrences of secondary uranium mineralization were found in granitic rocks of west-central Alaska (T. P. Miller), and sedimentary rocks at two localities in the Susitna lowlands were found to contain 3 to 4 times normal uranium values (K. A. Dickinson).

*Computer processing of multispectral aerial-scanner data for uranium areas of the Powder River Basin showed that field-identified red, drab, and white altered ground can be distinguished remotely (G. L. Raines).

*Work in the Newark Basin has led to the suggestion that iron and aluminum hydroxides on the surface of clay platelets, in an environment of pH <8, will attract organic anions to create a humic-rich locus for uranium fixation (C. E. Turner-Peterson).

*Beryllium and uranium of the Thomas Range, Utah, are found only in two topaz rhyolite tuff units 21 m.y. old; other similar but barren units are 6-7 m.y. old (D. A. Lindsey).

*The fluvial pattern of the Morrison Formation on the northwest

edge of the San Juan Basin was strongly influenced by tectonic structures that were active during sedimentation (A. C. Huffman).

*Borehole logging at uranium deposits in Texas, Wyoming, and Utah showed anomalies of resistivity, IP, and magnetic susceptibility that indicate mineralogic/geochemical halo features extending around deposits to distances of several deposit widths (J. H. Scott, J. J. Daniels).

*The uranium resource assessment effort produced models of most known major types of uranium occurrences, including lists of observations (recognition criteria) considered necessary in defining the genetic type of deposit and specific habitat.

PARTICIPATION IN THE DEPARTMENT OF ENERGY PROGRAM

USGS work on the NURE program will continue in FY 1979, but a change in emphasis and schedule of the program has required the recessing of work in 19 NTMS (National Topographic Mapping Service) 2-degree quadrangles and a speedup of evaluation studies in 23 quadrangles containing reserves and estimated potential resources. In addition, DOE is sponsoring geologic studies in areas similar in settings to those containing major ("world-class") non-sandstone uranium deposits. Other efforts will be directed toward rapid development and testing of resource-assessment methods. Coordination of work by the two agencies is proceeding through periodic meetings of two coordination groups and of working groups on specific aspects of the program.

As of September 1978, the USGS evaluation effort was focused on favorable areas in the following 2-degree quadrangles:

Richfield	Moab	Denver
Shiprock	Cortez	Greeley
Aztec	Ekalaka	Pueblo
Gallup	Gillette	Socorro
Albuquerque	Newcastle	Flagstaff
Price	Torrington	Delta
Salina	Craig	Walker Lake
Escalante	Vernal	

PUBLICATION RESULTS

Results from the program will be published as reports and maps on a timely basis. The principal publications of the U.S. Geological Survey are Professional Papers, Bulletins, Circulars, and various series of maps. Information of an urgent nature will be open-filed as soon as it is prepared. All reports and maps released by the U.S. Geological Survey are described in the monthly listing, "New Publications of the Geological Survey," which may be obtained free by application to the U.S. Geological Survey, National Center 329, Reston, VA 22092. Information not released directly by the U.S. Geological Survey will be published in various scientific journals.

From the expansion of the program in 1974 until the beginning of FY 1978, 148 published articles and maps, 152 open-file reports, and 98 abstracts were produced. In FY 1978, 24 journal articles, 4 maps, 32 open-file reports, and 13 abstracts were issued so as to be available to the interested public, and many other papers were approaching completion at the end of the fiscal year. In addition to written reports, much information, particularly preliminary results,

is presented orally or in poster sessions at scientific and industrial meetings.