New Mexico Geological Society

*Downloaded from:* https://nmgs.nmt.edu/publications/guidebooks/31




# *Uranium assessment along the Precambrian unconformity, Van Horn area, Texas*

Donald M. Davidson Jr., Gerald Edwards, and Philip C. Goodell
1980, pp. 251-256. https://doi.org/10.56577/FFC-31.251

*in:*

*Trans Pecos Region (West Texas)*, Dickerson, P. W.; Hoffer, J. M.; Callender, J. F.; [eds.], New Mexico Geological Society 31st Annual Fall Field Conference Guidebook, 308 p. https://doi.org/10.56577/FFC-31

*This is one of many related papers that were included in the 1980 NMGS Fall Field Conference Guidebook.*

## Annual NMGS Fall Field Conference Guidebooks

Every fall since 1950, the New Mexico Geological Society (NMGS) has held an annual Fall Field Conference that explores some region of New Mexico (or surrounding states). Always well attended, these conferences provide a guidebook to participants. Besides detailed road logs, the guidebooks contain many well written, edited, and peer-reviewed geoscience papers. These books have set the national standard for geologic guidebooks and are an essential geologic reference for anyone working in or around New Mexico.

### Free Downloads

NMGS has decided to make peer-reviewed papers from our Fall Field Conference guidebooks available for free download. This is in keeping with our mission of promoting interest, research, and cooperation regarding geology in New Mexico. However, guidebook sales represent a significant proportion of our operating budget. Therefore, only *research papers* are available for download. *Road logs*, *mini-papers*, and other selected content are available only in print for recent guidebooks.

### Copyright Information

Publications of the New Mexico Geological Society, printed and electronic, are protected by the copyright laws of the United States. No material from the NMGS website, or printed and electronic publications, may be reprinted or redistributed without NMGS permission. Contact us for permission to reprint portions of any of our publications.

One printed copy of any materials from the NMGS website or our print and electronic publications may be made for individual use without our permission. Teachers and students may make unlimited copies for educational use. Any other use of these materials requires explicit permission.

*This page is intentionally left blank to maintain order of facing pages.*

# URANIUM ASSESSMENT ALONG THE PRECAMBRIAN UNCONFORMITY, VAN HORN AREA, TEXAS

DONALD M. DAVIDSON, JR., GERALD EDWARDS and PHILIP C. GOODELL
Department of Geological Sciences
University of Texas at El Paso
El Paso, Texas 79968

## INTRODUCTION

The purpose of this study was to investigate an area in the vicinity of Van Horn, Texas in order to assess the potential for non-sandstone-type uranium mineral resources (fig. 1). This research effort focused on geological units of Precambrian age which were remapped (in part), selectively sampled and chemically analyzed. Results of the present study together with available geological, geophysical and geochemical data were then compiled and compared with standard criteria of recognition which are presently accepted and utilized in the exploration for such deposits.

The Van Horn area was selected not only because the Precambrian rocks there have proven mineral resources (King and Flawn, 1953), but because the lithologies and structural relationships exhibited by these Proterozoic units indicated considerable potential for the occurrence of non-sandstone-type uranium anomalies. "World-class" Proterozoic unconformity-type deposits (Kalliokoski and others, 1978; Hegge and Rowntree, 1978; Dahlkamp, 1978; Hoeve and Sibbald, 1978) were of particular interest, although volcanic regimes (Goodell and others, 1979) were also considered.

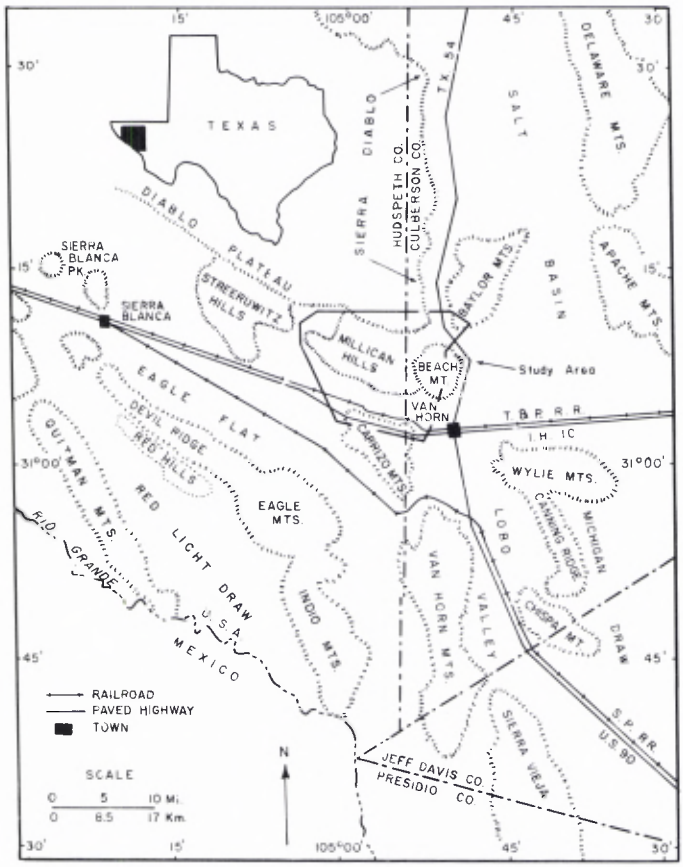



*Figure 1. Physiographic map of West Texas, showing study area (after Wiley, 1970).*

The study area is trapezoidal in shape and covers approximately 360 km² within the Trans-Pecos region of West Texas (fig. 1). The northern boundary of the area extends from 24 km northwest of the city of Van Horn and west of State Highway 54 in a west-southwesterly direction along the foothills of the Diablo Plateau, a distance of some 24 km. The southern boundary extends from 5 km west southwest of Van Horn and south of Interstate Highway 10 approximately 11 km due west.

## MODEL DEPOSITS

Two idealized "type" or "model" uranium deposits can be utilized in exploration for uranium in the Van Horn area. The first type is the "Proterozoic-unconformity" or "vein-breccia" model (Kalliokoski and others, 1978), and the second is in direct association with volcanic rocks (Goodell and others, 1979).

The first type of deposit, the Proterozoic-unconformity or vein-breccia type, occurs in or near breccia zones within fractured, carbon-rich basement rocks near unconformities with overlying unmetamorphosed fluvial strata of Proterozoic age (Deery, 1973). Examples of this class of deposit include those in western Saskatchewan (Rabbit Lake, Key Lake, Cluff Lake and Beaver Lodge) and in the Northern Territory of Australia (Rum Jungle, Pine Creek, Alligator River). These deposits consist dominantly of pitchblende and exhibit a fair degree of structural control along fault zones, together with extensive wallrock alteration (fig. 2).

The origin of this class of deposit is somewhat controversial. Some of these deposits have been interpreted as being of primary, epigenetic, "hydrothermal" origin (Deery, 1973), whereas other deposits are interpreted as being syngenetic in origin. The latter deposits are explained by the *in situ* leaching of uranium by oxidizing solutions in porous, fluvially derived cover rocks of Proterozoic age. Uranium is ultimately precipitated along fractures in basement rocks where reducing conditions are prevalent (Kalliokoski and others, 1978).

The application of this model to the Van Horn project resulted in close-spaced (400 m) geochemical sampling and gamma-spec-

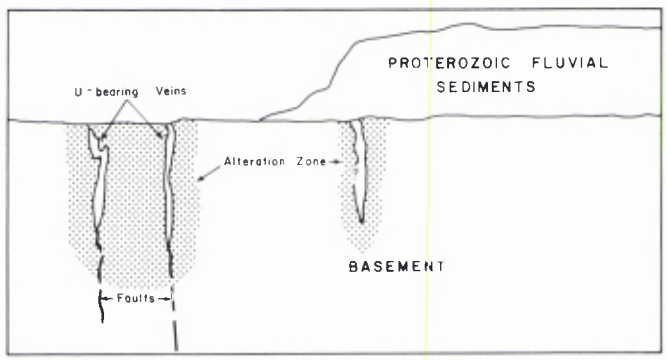



*Figure 2. Idealized representation of the occurrences of "Proterozoic-unconformity"-type uranium deposits.*

trometer field analysis at, above and below the unconformity between the Van Horn Sandstone and older units.

The second type of deposit is that in which uranium mineralization is found to occur as a direct result of concentration through volcanic activity. Specifically such deposits occur in ash-flow tuff sheets, frequently associated with rhyolite, of peralkaline composition. Noted examples include Peña Blanca, Chihuahua City, Mexico (Goodell and others, 1979), the McDermitt Caldera Complex, Nevada (Rytuba and Conrad, 1979), Marysvale, Utah (Cunningham and others, 1980) and elsewhere worldwide. Such deposits are commonly associated with caldera formation, attendant ring fracture development and resurgence. In many cases uranium appears to have been deposited from fluorine-rich solutions. Alteration may be present and is generally of low intensity and variable degree of development.

The consideration of volcanogenic uranium deposits of Precambrian age as a valid target for the development of resource potential is emphasized by the recent report of significant occurrences of commercial grade deposits in Proterozoic tuffs in Labrador (Gandhi, 1978). The Carrizo Mountain Group in the Van Horn area appears to be part of a widespread Precambrian ignimbrite province, including the Franklin Mountains, West Texas, and perhaps as far east as the St. Francois Mountains of Missouri.

The application of this model to the Van Horn project resulted in closely spaced (400 m) geochemical sampling and gamma spectrometer field analysis of units of the Carrizo Mountain Group, including rhyolite volcanics, to determine if anomalies exist.

## ANALYTICAL GEOCHEMICAL STUDIES

### Introduction

Geochemical and geological data were obtained at 340 locations, and 27-element determinations were carried out on each sample using standardized NURE techniques at the Oak Ridge National Laboratory. Values for three elements (U, K, Th) were also determined utilizing standard techniques on 500-gram sample splits for all 340 locations at the Gamma Ray Spectroscopy Laboratory, University of Texas, El Paso.

The sample population was grouped into seven types based on factors related to their geologic occurrence. These groupings included samples from:

1. The Carrizo Mountain Group (PCCM)
2. The Allamoore Formation (PCA1, PCAP, PCAV)
3. The Hazel Formation (PCNC, PCMs)
4. The Van Horn Sandstone (PCVS)
5. Along the unconformity beneath the Hazel Formation (AAAA, BBBB, CCCC)
6. Along unconformities beneath the Van Horn Sandstone with other Precambrian units (VVVV, WWWW, XXXX, YYYY)
7. Along fault contacts between the Van Horn and other Precambrian units (FVAL, FVHS).

### Discussion of Histogram and Percentile Plots

The data derived from these elemental analyses have been subjected to various statistical manipulations. The range of variation in and frequency behavior of values for uranium, thorium, vanadium and total gamma radiation are shown by the histograms and log-normal probability diagrams in Figure 3.

As the behavior of uranium is of primary interest to this study, it is noteworthy that 97 percent of the uranium values as determined by the various techniques fall below 10 ppm, although anomalous values do exist and these will be discussed below. Total uranium, as determined by neutron activation, techniques, has a mean value of 2.95 ppm, which is slightly depleted with respect to values from granitic rocks, although typical of those from a shale-limestone mixture. Equivalent uranium has a mean value of 2.89 (Oak Ridge) and 2.90 (UTEP). These values are quite close to the mean value for total uranium (2.95), indicating that the uranium present is, for the most part, in secular equilibrium.

The mean value of thorium at 6 ppm is lower than that commonly expected for either granites or continental sediments; the Th/U ratio of 2 is also low.

### Discussion of Correlation Coefficients for Uranium with Other Elements

Correlation coefficients of the various elements with respect to uranium are summarized in Table 1, which portrays results of a cluster analysis applied to the 27 elemental values.

Although uranium does not correlate with any particular element, coefficients with P, As, Y and Zr render the highest values, ranging between 0.35 and 0.45. While P, As, Y and Zr show the highest correlation coefficients with uranium, the summary provided in Table 1 of the coefficients of these elements indicate that the geochemical environment responsible for this relationship is largely that of association with lithophile elements, particularly rare earth elements, which possibly occur in minerals such as monazite (a phosphate) and zircon.

To a lesser extent uranium appears to be associated with siderophile elements, such as arsenic, which commonly occur in a base-metal sulfide environment. It appears remotely affiliated with phosphorous, and even less so with lithium; a general association with Ce, Sr, Ca, Mg and Se is suggested.

### General Statements Relating Element Distribution with Geologic Environment

Median values, maximum-minimum values, and selected percentile increments for uranium, thorium, potassium and total gamma radiation are plotted by geologic sample type in Figure 4.

Positive elemental affiliations with uranium include: 1) Ag, Zn, Cu; 2) Sc, V, Cr, Ni, Co, Fe; and 3) Al, Ti, K, Y, Zr. These three groupings may be geochemically classified as 1) a base-metal, chalcophile element suite; 2) a mafic, lithophile element suite, and 3) a lithophile, rare earth element suite, respectively. These geochemical affinities are characterized by various geologic environments or units which have been identified in the Van Horn area. The base-metal suite (Ag, Zn, Cu) is related to widespread polymetallic sulfide mineralization, commonly along fault zones as evidenced by numerous such occurrences throughout the region, particularly in the Hazel Sandstone. Several abandoned mines exploited small base-metal sulfide deposits.

The lithophile-mafic element suite (Sc, V, Cr, Ni, Co, Fe) is apparently related to numerous mafic volcanic rocks in the region, particularly in the Carrizo Mountain Group. Members of this suite, such as Ni and Co, are traditionally associated with uranium in unconformity-related geologic environments. However, Ni and Co are not closely related to uranium in this project area.

The rare earth suite appears to be generated from the presence of the metamorphosed rhyolitic tuff of the Carrizo Mountain Group, which is late Precambrian in age. This unit is anomalously enriched in uranium, rare earth (Ce, Y ,Nb) and lithophile elements (Be, Th, Zr) compared to other rock types of the region. Although comparisons have not been made with those for other Precambrian ash-flow tuffs, the values of 3.4 ppm for total uranium and

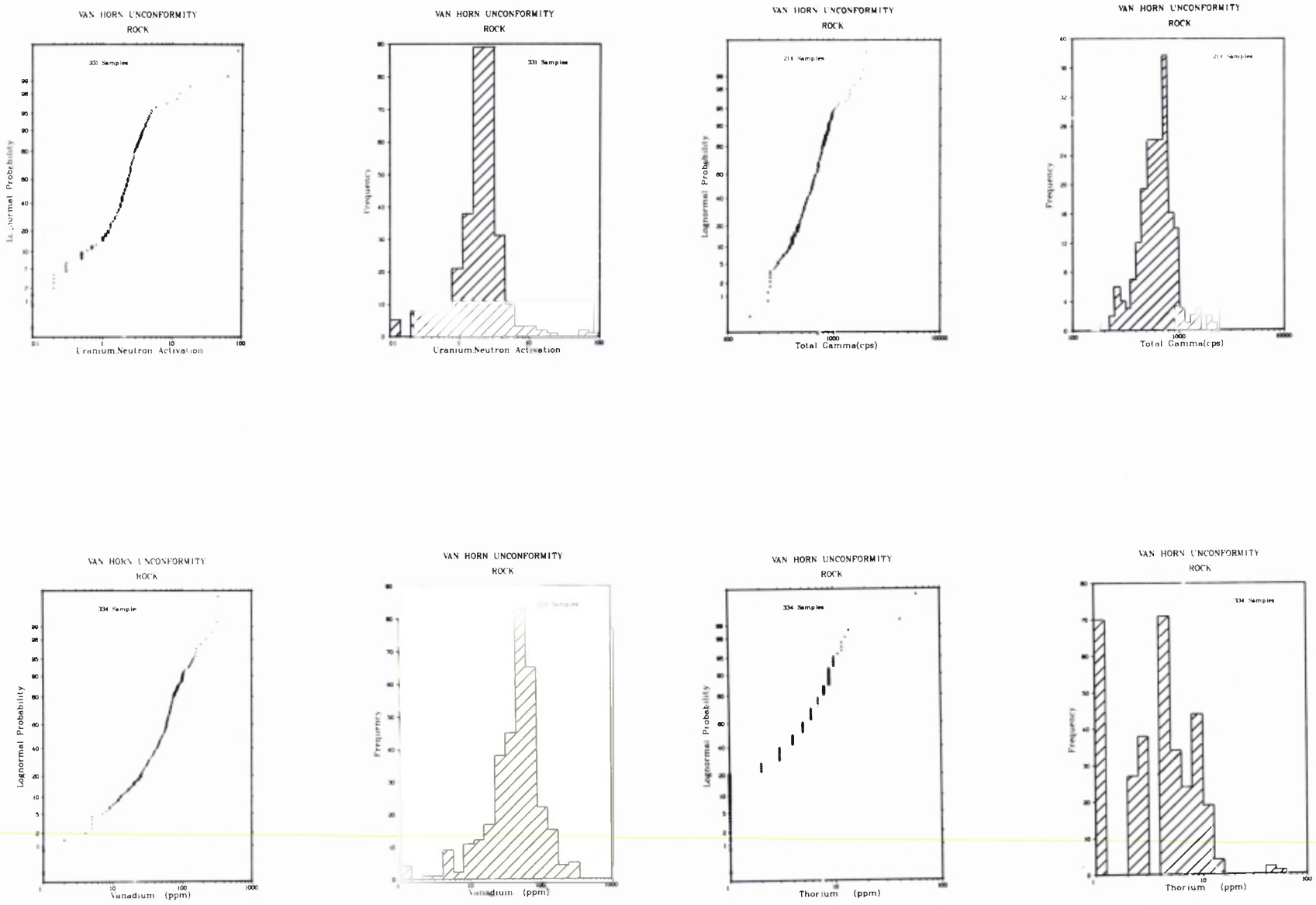



*Figure 3. Elemental analyses of selected samples, Van Horn investigation, West Texas.*

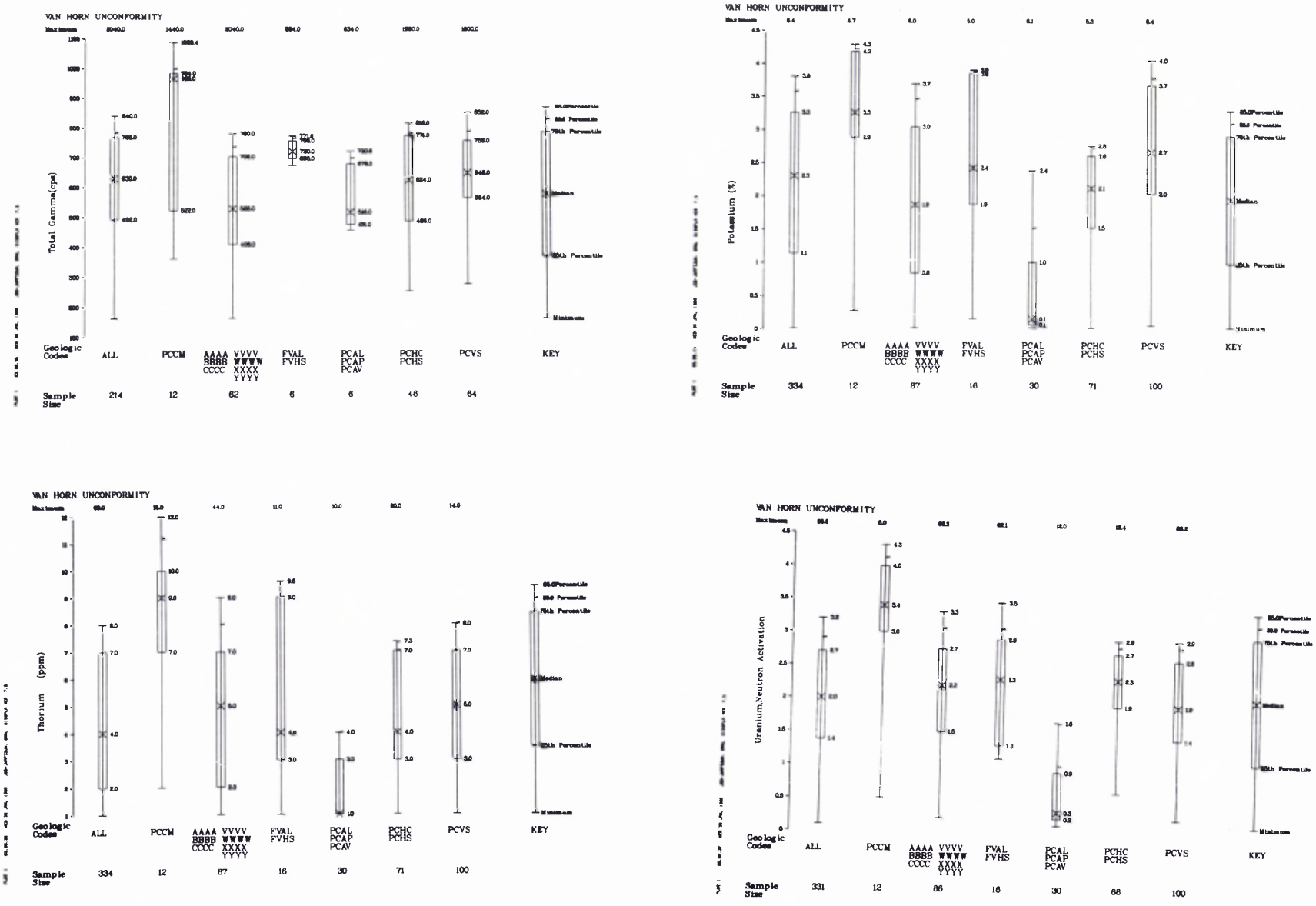



*Figure 4. Median value, range and selected percentile increments of value for various elemental analysis plotted against geological sample type, Van Horn area, Texas. See text for explanation.*

*Table 1. Ranges of values of correlation coefficients for Uranium with other selected elements.*

| Ranges of Values of Correlation Coefficients | U with | P with | As with | Y with | Zr with | Ni with |
|---|---|---|---|---|---|---|
| Greater than 0.45 | none | Sc,V,Cr, Co,Fe,Y | | P,Ce,Sc, Cr,Fe,Th, Al,Ti,K, | Ce,Sc,Fe, Al,Ti,K, Y | Sc,V,Cr, Li,Co,Fe, Al,Ti |
| $0.35<x\leq0.45$ | P,As,Y, Zr | Al,Ti,U | U | V,Ni,Mn, Nb,U,Ba | U,V,Cr, Th,Nb,Ba | Zn,Na,Mn, Y |
| $0.25<x\leq0.35$ | Th,K | Cu,Ni,Na Zr | Zn,Cu | | P,Ni | P,K,Zr |
| $0.15<x\leq0.25$ | Ce,Cu,Sc, V,Fe,Nb, Al,Ti,Ba | Li,Se,As Zn,Mn,Th, K | P,Sr,Se V,Cr,Co Ba | Zn,Co.Na | Se,Co,Na | Ce,Ba, |

3.0 ppm for thorium appear unusually high for a tuff which has been subjected to devitrification, diagenesis and low-grade metamorphism.

## SUMMARY

Uranium assessment along the Precambrian unconformity near Van Horn, Texas has revealed three anomalous areas which occur in three distinctive geologic settings (Davidson and others, 1980). These settings are: 1) within tuff units of the Carrizo Mountain Group, 2) within folded units of the Allamoore Formation (Garren Ranch site), and 3) along a mineralized normal fault which juxtaposes units of the Allamoore Formation and Van Horn Sandstone (Dallas Fault site). Measured values for uranium, potassium and thorium are given for each of these sites in Tables 2, 3, and 4, respectively.

It is suggested that the Carrizo Mountain Group is a possible exploration target for uranium deposits, either of the Proterozoic unconformity type or of the volcanogenic-leaching type in volcanic and volcaniclastic rocks. Uranium occurrences of possible economic significance have recently been discovered in rhyolitic ash-flow tuffs of Precambrian age in Labrador and in Sweden, making this suggested target quite explicit.

*Table 2. Values for U, Th, K at the Carrizo Mountain Group anomalous area, Van Horn project, as measured on gamma spectrometer, U. T. El Paso, and for U (ppm), determined chemically at Oak Ridge National Laboratories [expressed as U ppm (OR)]*

| Sample Number | Th ppm | U ppm | U ppm (OR) | K % | Th/U | Th/K |
|---|---|---|---|---|---|---|
| 608 | 13.67 | 3.71 | 4.1 | 3.80 | 3.68 | 3.60 |
| 598 | 14.04 | 2.91 | 2.1 | 3.89 | 4.82 | 3.61 |
| 603 | 9.91 | 2.44 | 2.4 | 4.65 | 4.06 | 2.15 |
| 597 | 11.84 | 3.01 | 2.4 | 3.91 | 3.93 | 3.03 |
| 604 | 4.88 | 2.94 | 2.7 | 3.32 | 1.66 | 1.47 |
| 611 | 5.93 | 4.11 | 3.2 | 5.81 | 3.89 | 2.75 |
| 605 | 5.01 | 1.91 | 2.1 | 4.72 | 2.62 | 1.06 |
| 722 | 13.86 | 3.53 | 2.4 | 6.50 | 3.93 | 2.17 |
| 595 | 12.25 | 3.40 | 3.8 | 4.67 | 3.60 | 2.62 |
| 596 | 19.85 | 2.89 | 1.7 | 4.92 | 6.87 | 4.03 |

The total ground gamma radiation response was significantly higher in units of the Carrizo Mountain Group, as expressed by a median value of 955 cps in contrast to an overall average of 630 cps for all units. As ground gamma radiation, laboratory gamma radiation, and total uranium responses differ between the Carrizo Mountain Group and other geologic units by the same proportions, units of the Carrizo Mountain Group are easily identifiable in ground surveys.

The anomalous area in the Allamoore Formation is also characterized by high values of Li and P and low values of Ce, Zr, Y, Th,

*Table 3.*

*A. Values for U, Th, K at the Garren Ranch anomaly, Van Horn project, as measured on gamma spectrometer, U. T. El Paso.*

| Sample Numbers | Th(ppm) | U(ppm) | K(%) | Th/U | Th/K |
|---|---|---|---|---|---|
| A1 | .39 | .52 | .39 | 0.75 | 1.00 |
| A2 | .63 | .47 | .12 | 1.34 | 5.16 |
| A3 | 1.84 | 3.31 | .04 | 0.56 | 38.6 |
| A4 | 6.42 | 6.05 | .16 | 3.15 | 38.3 |
| B1 | .56 | .18 | .00 | 3.15 | 61.8 |
| B2 | 3.07 | 4.22 | .03 | 0.73 | 77.5 |
| B3 | 1.23 | .87 | .30 | 1.42 | 4.12 |
| B4 | .82 | .58 | .21 | 1.42 | 3.89 |
| C1 | .47 | .18 | .04 | 2.58 | 10.36 |
| C2 | 2.27 | .42 | .21 | 0.66 | 10.79 |
| C3 | 1.08 | .94 | .52 | 1.14 | 2.08 |
| C4 | .62 | .65 | .23 | 0.95 | 2.61 |
| D1 | .67 | .67 | .33 | 0.99 | 1.99 |
| D2 | .98 | .43 | .32 | 2.26 | 3.06 |
| D3 | 1.02 | .48 | .13 | 2.11 | 7.44 |
| D4 | .73 | .45 | .23 | 1.61 | 3.14 |
| E1 | .59 | .42 | .14 | 1.39 | 4.16 |
| E2 | .58 | .51 | .24 | 1.14 | 2.40 |
| E3 | 1.25 | .71 | .11 | 1.76 | 10.95 |

*B. Values of chemical analyses on selected samples associated with the Garren Ranch anomaly, Van Horn project. Analyses carried out by Oak Ridge National Laboratories.*

| Sample Numbers | Th(ppm) | U(ppm) | K(%) | Th/U | Th/K |
|---|---|---|---|---|---|
| 583 | 5.0 | 1.14 | 0.43 | 4.38 | 11.63 |
| 584 | 4.0 | 0.98 | 0.13 | 4.08 | 30.77 |
| 585 | 3.0 | 1.69 | 0.01 | 1.78 | 30.0 |
| 586 | 3.0 | 15.45 | 3.83 | 0.19 | 0.78 |
| 587 | 5.0 | 1.94 | 0.70 | 2.58 | 7.14 |
| 588 | 0 | 14.42 | 3.45 | 0.42 | 1.74 |
| 590 | 3.0 | 1.60 | 0.67 | 1.88 | 4.48 |
| 591 | 13.0 | 1.78 | 1.79 | 7.3 | 7.3 |
| 592 | 6.0 | 2.10 | 2.17 | 2.85 | 2.76 |
| 593 | 3.0 | 2.75 | 0.16 | 1.09 | 18.75 |
| 594 | 60.0 | 10.34 | 4.23 | 5.80 | 14.18 |
| 679 | 44.0 | 74.65 | 1.07 | 0.59 | 41.12 |
| 680 | 5.0 | 2.90 | 0.18 | 1.72 | 27.78 |
| 681 | 42.0 | 4.90 | 2.56 | 8.57 | 16.40 |

*Table 4.*

*A. Values for U, Th, K along Dallas Fault anomaly, Van Horn project, as measured on gamma spectrometer, U. T. El Paso.*

| Sample Number | Th(ppm) | U(ppm) | K(%) | Th/U | Th/K |
|---|---|---|---|---|---|
| A1 | 2.68 | 1.083 | .05 | 25.48 | 2.48 |
| A2 | .39 | .485 | .40 | 0.81 | 0.98 |
| A3 | .35 | .80 | .47 | 0.94 | 0.75 |
| B1a | 2.00 | .976 | .15 | 2.06 | 12.70 |
| B1b | 1.34 | .727 | .37 | 1.85 | 3.63 |
| B2 | .7 | .724 | .33 | 1.05 | 2.27 |
| B3 | .35 | .725 | .09 | 0.49 | 7.44 |
| B4 | .22 | .24 | .06 | 0.85 | 3.19 |
| C1 | 1.58 | 4.04 | .50 | 0.39 | 3.11 |
| C2 | 1.98 | 2.32 | .16 | 0.85 | 11.76 |
| C3 | .46 | .23 | .09 | .99 | 4.75 |
| C4 | .6 | .415 | .16 | 1.24 | 3.79 |
| D1 | .88 | .95 | .43 | 0.94 | 2.04 |
| D2 | .80 | .298 | .07 | 2.69 | 10.83 |
| D3 | 2.31 | 3.00 | -0.0 | 0.77 | -341.84 |
| D4 | .87 | .6 | .37 | 1.67 | 2.33 |

*B. Values measured at Oak Ridge National Laboratories for samples from same vicinity as those of Table 4A.*

| Sample Number | Th(ppm) | U(ppm) | K(%) | Th/U | Th/K |
|---|---|---|---|---|---|
| 2729 (508) | 4.0 | 5.8 | 5.8 | 0.69 | 0.69 |
| (509) | 9.0 | 1.3 | 3.9 | 6.92 | 2.31 |
| (510) | 1.8 | 1.0 | 0.15 | 1.8 | 12.0 |
| 2721 (403) | 7.0 | 60.0 | 3.9 | 0.12 | 1.79 |
| 2722 (404 | 7.0 | 1.3 | 4.5 | 5.38 | 1.56 |
| (405) | 1.8 | 2.9 | 1.9 | 0.62 | 0.95 |
| 2866 (599) | .0 | 81.42 | 2.26 | 0.05 | 1.77 |
| 2867 (606) | 10.0 | 22.32 | 3.63 | 0.45 | 2.75 |
| 2868 (600) | 3.0 | 1.42 | 0.12 | 2.11 | 25.0 |
| 2869 (607) | 10.0 | 11.05 | 0.23 | 0.90 | 43.48 |

Nb and Be. This is directly attributable to the predominantly carbonate character of the unit. It is believed the anomalous uranium concentrations occur in minerals rich in lithophile and rare earth elements.

Sulfide mineralization is prevalent along the Dallas Fault; thus, it is believed that the uranium concentrations producing the anomaly occur in association with a typical base-metal assemblage.

These three anomalous occurrences represent possible viable exploration targets within the framework of the models presented. Clearly, additional exploration efforts appear warranted, given the limited exposure of the Precambrian unconformity in the region.

## REFERENCES


Cunningham, C. G., Steven, T. A., Rasmussen, J. T. and Romberger, S. B., 1980, The genesis of the Marysvale, Utah, hydrothermal uranium deposits (abstract): Geological Society of America Abstracts with Programs, v. 11, p. 408.

Dahlkamp. F. J., 1978, Geological appraisal of the Key Lake U-Ni deposits, northern Saskatchewan: Economic Geology, v. 73, p. 1430-1449.

Davidson, Jr., D. M., Edwards, G, and Goodell, P. C., 1980, Investigations of the uranium potential along the Proterozoic unconformity in the Van Horn Area, Texas: U.S. Department of Energy, Open-File Report 97-80, 64 p.

Deery, D. R., 1973, Ore deposition and contemporaneous surfaces: Economic Geology, v. 68, p. 1374-1380.

Gandhi, S. S., 1978, Geological setting and genetic aspects of uranium occurrences in the Kaipokok Bay–Big River area, Labrador: Economic Geology, v. 73, p. 1492-1522.

Geometrics, 1978, Aerial gamma ray and magnetic survey, Van Horn and Pecos quadrangles, Texas: U.S. Department of Energy, Open-File Report GJBX-2 (78).

Goodell, P. C., Trentham, R. C. and Carraway, K. E., 1979, Geologic setting of the Peña Blanca uranium deposits, Chihuahua, Mexico: U.S. Department of Energy, Open-File Report GJBX-11-179, Chapter 9, p. 1-38.

Hegge, M. R. and Rowntree, J. C., 1978, Geologic setting and concepts on the origin of uranium deposits in the east Alligator River region, N. T., Australia: Economic Geology, v. 73, p. 1420-1429.

Hoeve, J. and Sibbald, T. I. I., 1978, On the genesis of Rabbit Lake and other unconformity-type uranium deposits in northern Saskatchewan, Canada: Economic Geology, v. 73, p. 1450-1743.

Kalliokoski, J., Langford, F. F. and Ojakangas, R. W., 1978, Criteria for uranium occurrences in Saskatchewan and Australia as guides to favorability for similar deposits in the United States: U.S. Department of Energy Open-File Report GJBX-114(78).

King, P. B. and Flawn, P. T., 1953, Geology and mineral deposits of Precambrian rocks of the Van Horn area, Texas: University of Texas Publication 5301, 218 p.

Rytuba, J. J. and Conrad, W. K., 1979, Structural and petrologic association of uranium deposits within the McDermitt Caldera complex, Nevada–Oregon (abstract): Geological Society of America, Abstracts with Programs, v. 11, p. 508-509.

Wiley, M. A., 1970, Correlation of geology with gravity and magnetic anomalies Van Horn–Sierra Blanca region, Trans–Pecos, Texas (Ph.D. dissertation): University of Texas, Austin, 351 p.