

**Exploration and discovery of blind breccia pipes - the potential significance to the uranium endowment of the Arizona Strip District, Northern Arizona**

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VP Exploration**

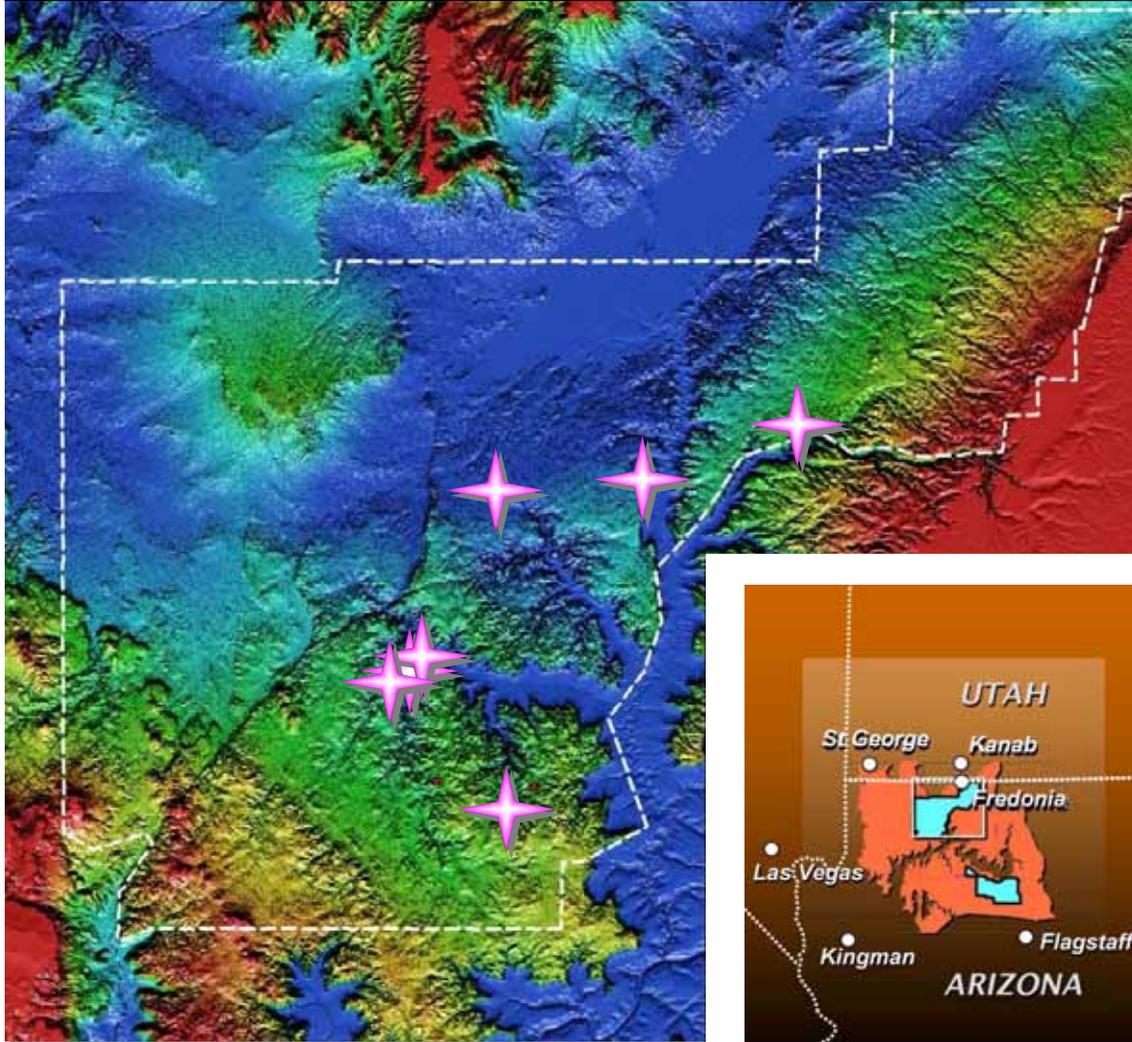


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Keystone, CO USA

## Northern Arizona Strip Uranium District



### ***The Last Hard Rock Uranium Producer in the U.S.***

- 1000 sq miles in Colorado Plateau Province of NW Arizona
- From 1980 to 1990, Energy Fuels Nuclear produced 19 million lbs of  $U_3O_8$  from 7 breccia pipes
- Average grade of 0.64%  $U_3O_8$  places these deposits among the highest grade in the U.S.

## Why the last hard rock uranium producer in the in the US?

Reclaimed Hack Canyon Mine



### ***Economical***

- High Grades , no ground water
- Excellent rock conditions
- “Cookie Cutter” permitting, mine design and development

### ***High grades and small mines***

- Short development time: 3yrs from discovery to mining
- Small footprint: mine complex < 20 acres
- Easy reclamation: waste pushed back in mine shaft and surface reclaimed

***Exploration and development is quick***

***Production is clean and economical***

***Reclamation can be nearly perfect***

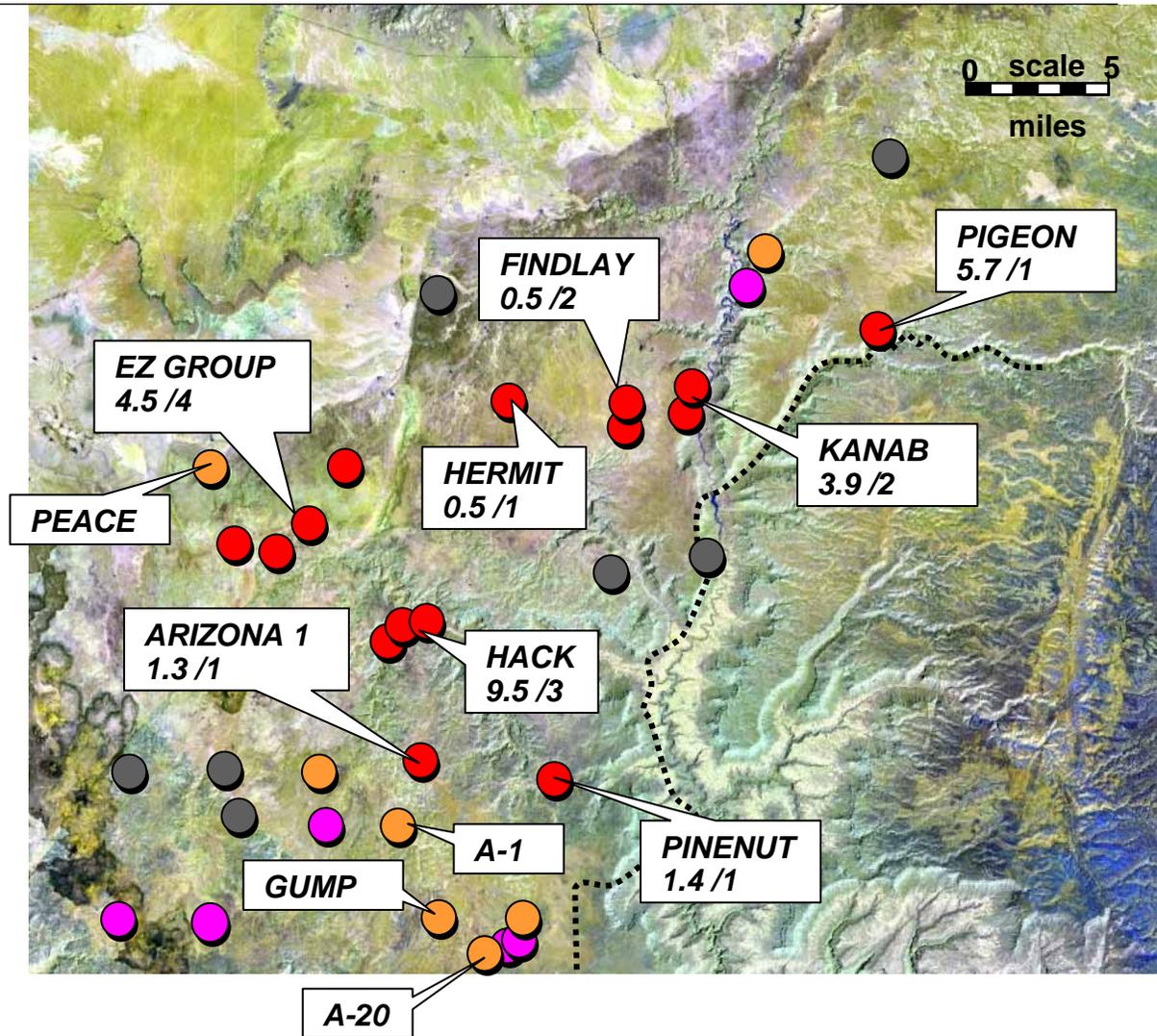
Reclaimed Pigeon Mine



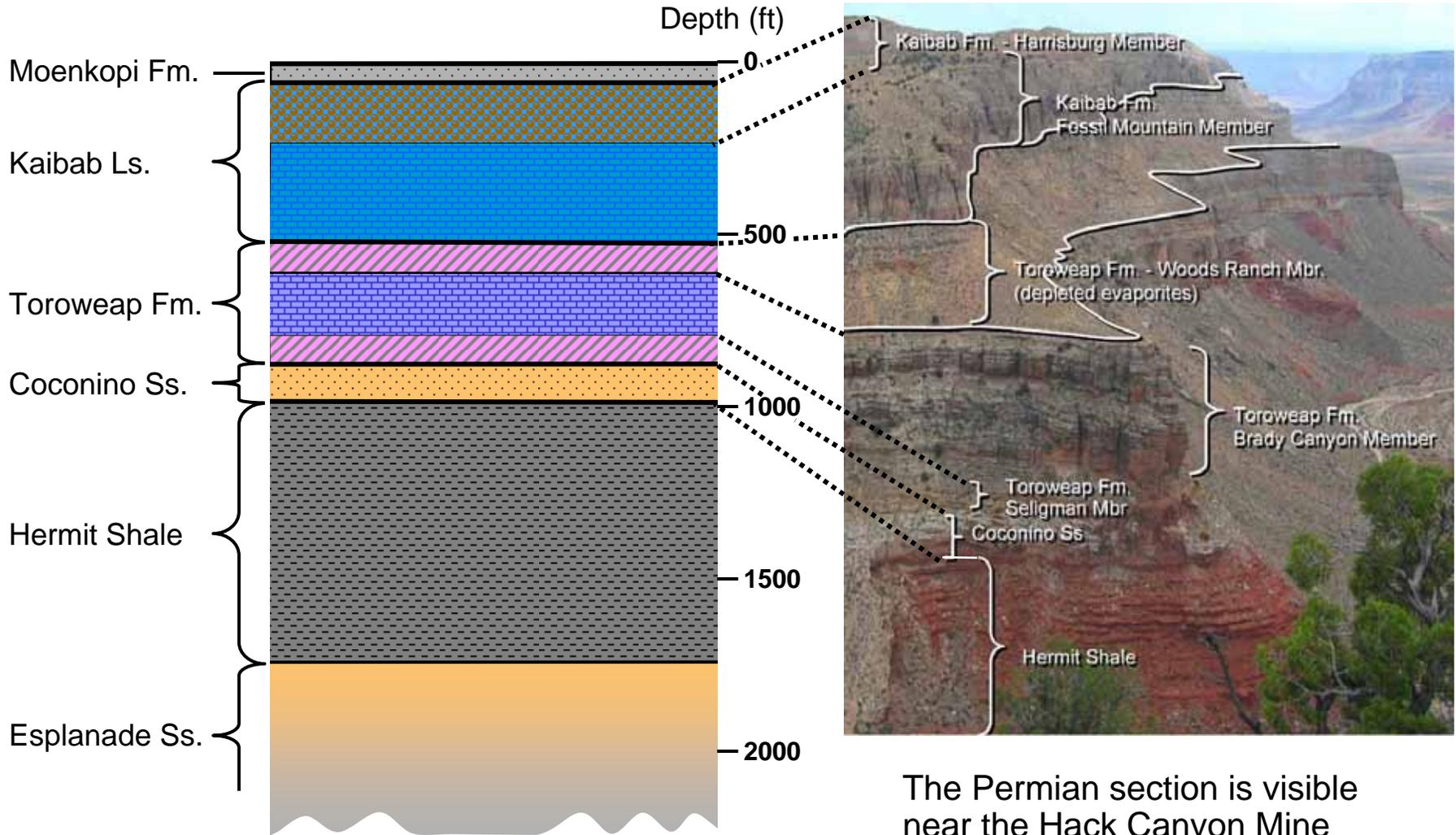
## Northern Arizona Strip Uranium Deposits

*Historically defined reserves and resources of 27 million pounds  $U_3O_8$  in 15 breccia pipes (1.8 million lbs  $U_3O_8$  per pipe)*

- Reserves/production  
M lbs  $U_3O_8$  / # pipes
- 7 Mineralized
- 6 Barren
- 6 under exploration

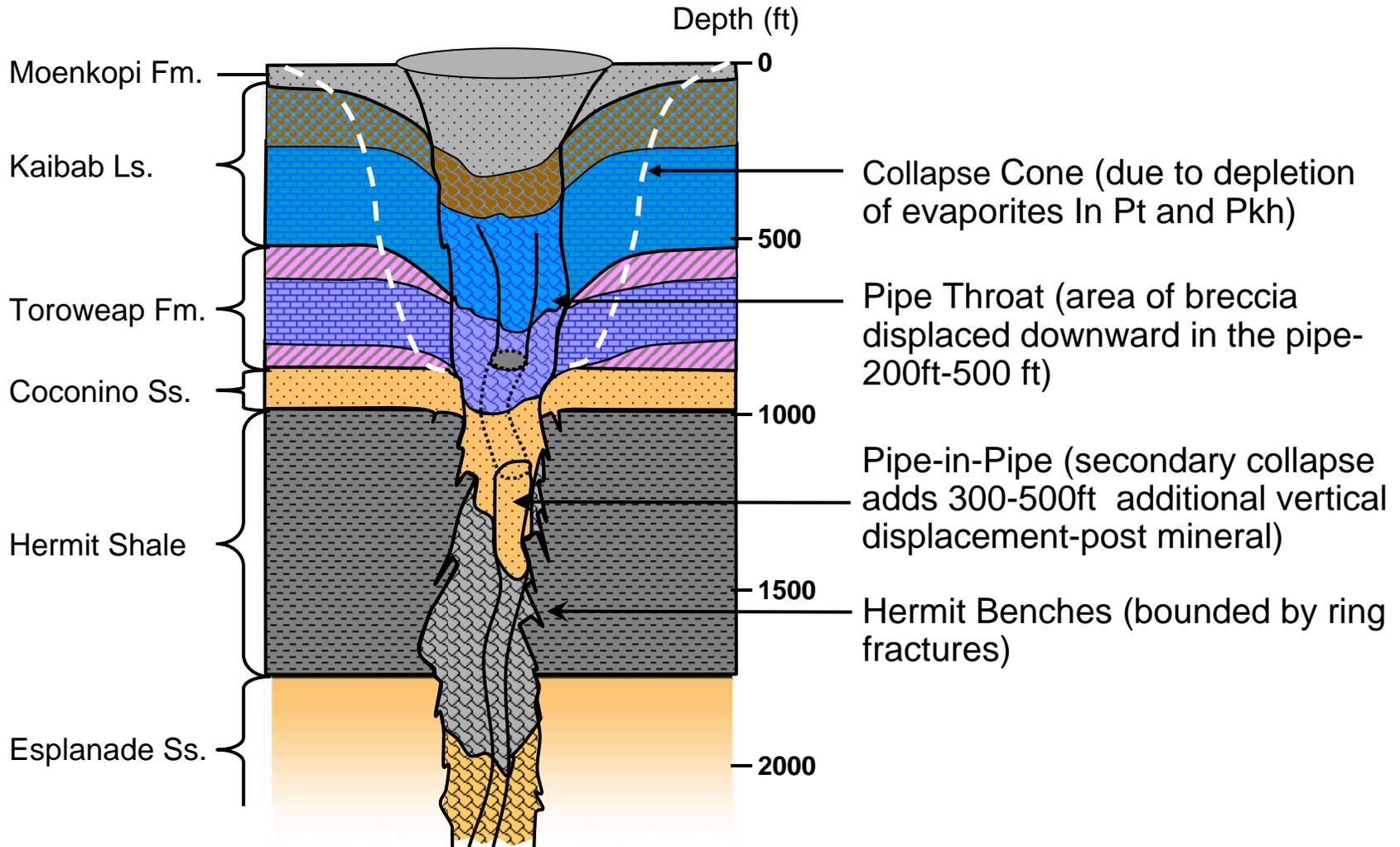


# Arizona Strip Stratigraphy

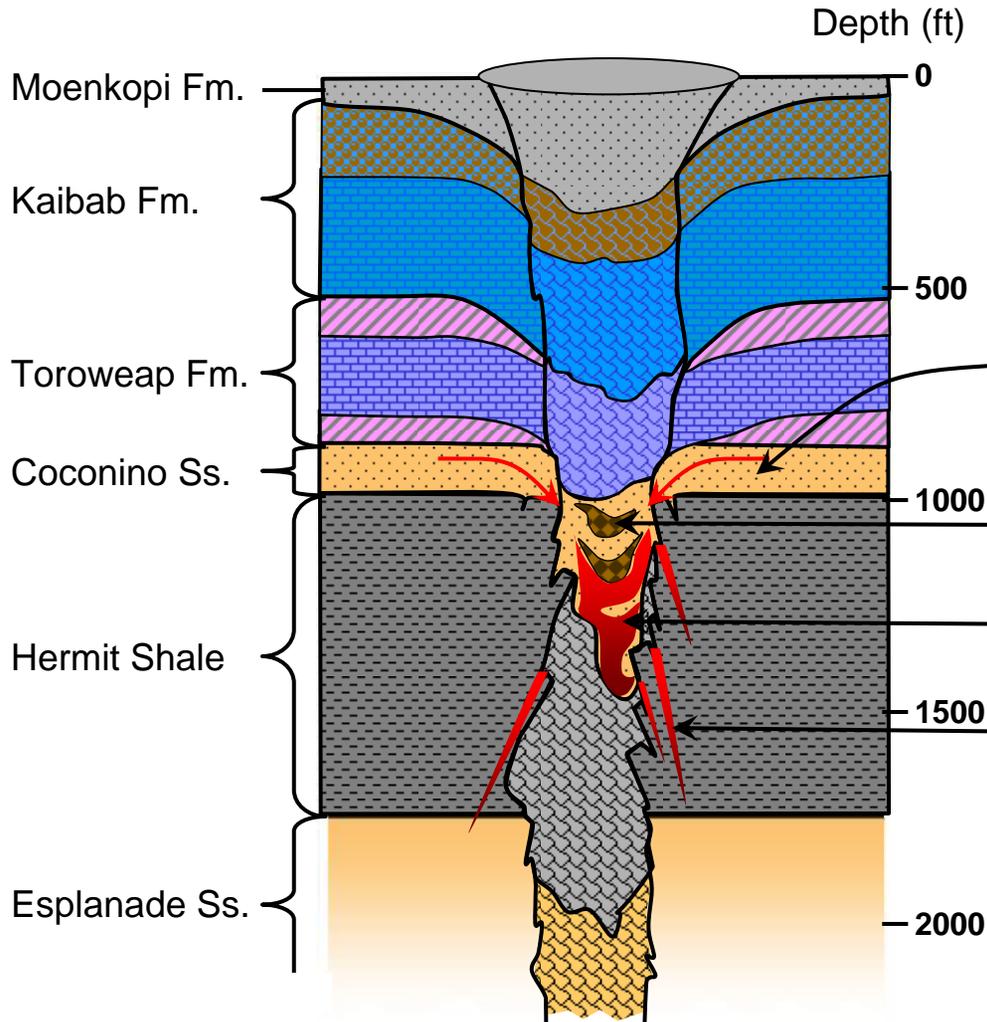


The Permian section is visible near the Hack Canyon Mine

# Breccia Pipe Morphology



# Breccia Pipe Mineralization



**U source is believed to be volcanic ash of the Late Triassic Chinle Formation transported by groundwater in the Coconino Ss. (Ludwig and Simmons, 1992)**

Coconino Ss acts as conduit for U mineralization and host as Ss dominant breccia in pipe

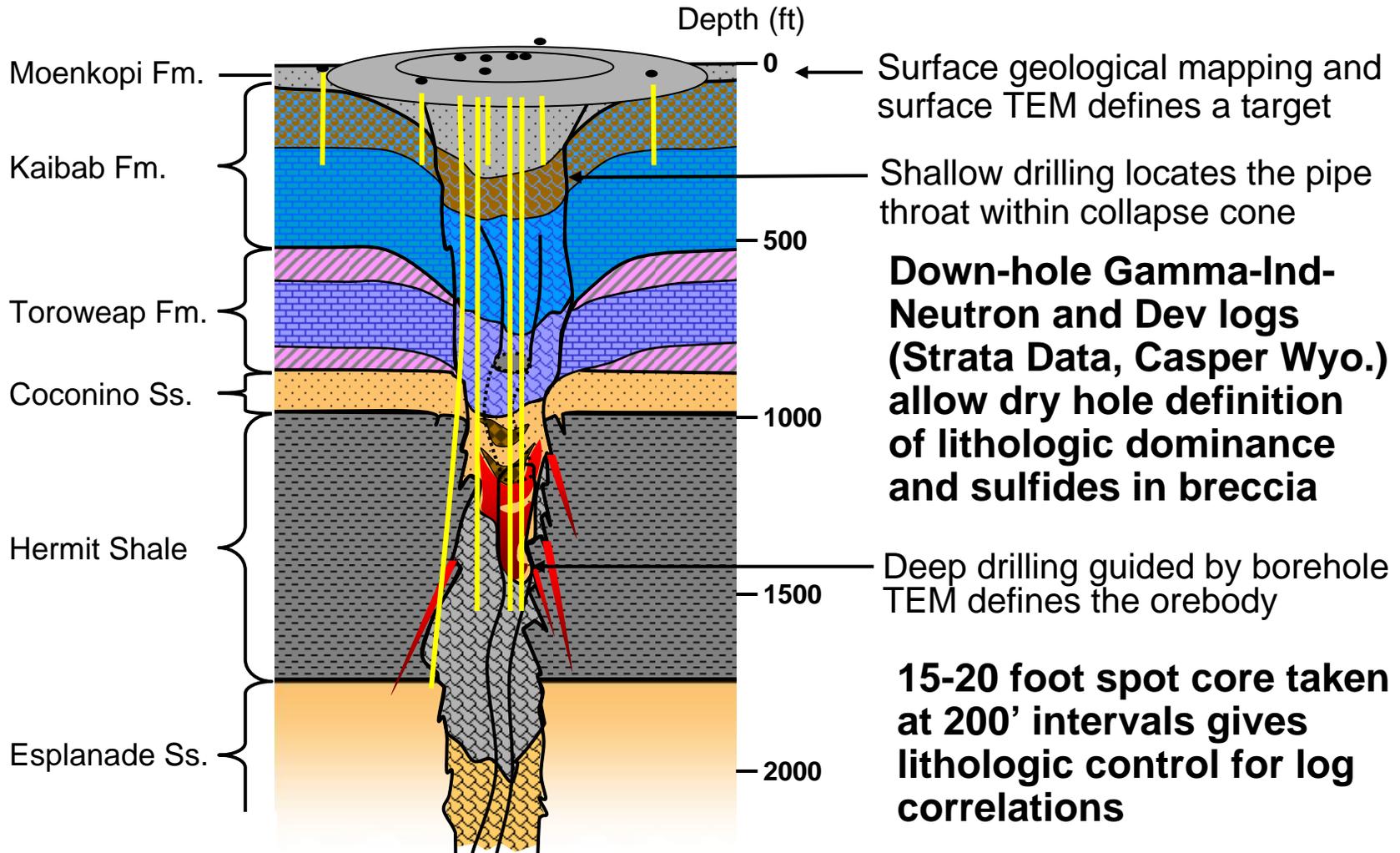
**Pyrite Cap** (py after marcasite) <50 ft thick

**Coconino Ss dominant breccia hosted U mineralization**

**Ring fracture hosted U mineralization**

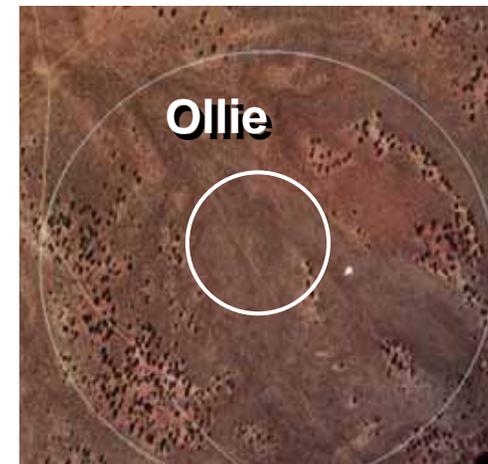
- U occurs as pitchblende.
- Calcite and gypsum are cementing minerals.
- Trace elements include Cu, As, Ni, Pb, Zn and Ag.

# Breccia Pipe Exploration



## Breccia Pipe Surface Expression

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## Sunshine Breccia Pipe - Barren



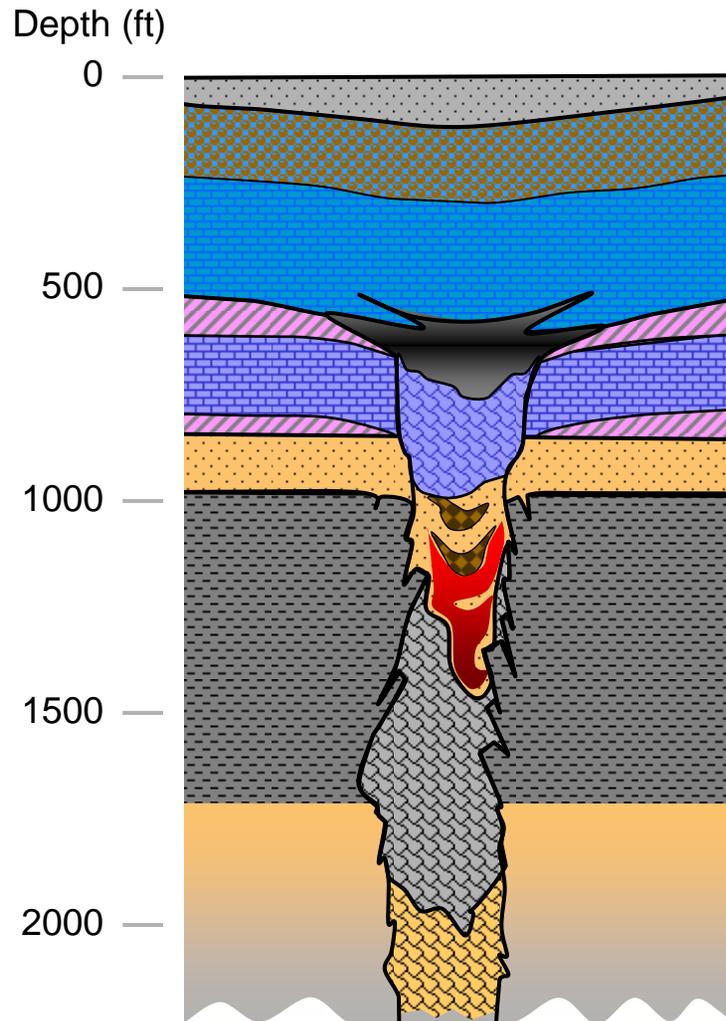
### ***Some pipes collapse too much***

- One of the largest vertical displacements of breccia in pipes of the northern district
- Outcrops of Upper Triassic Shinarump ss visible in the center of a collapse cone in near the top of at Pkfm
- < 1200 feet of vertical displacement

- Drilled to a depth of 1,580 feet – barren
- Favorable Coconino Ss dominant breccia horizon has probably dropped to into the Redwall Ls. and well below economic potential.



## Blind Pipe Geometry



### ***Other pipes don't reach the surface***

- Blind pipes may potentially be larger deposits
- Hack 2 (7 million lbs  $U_3O_8$ ) did not reach the surface and is the largest deposit ever found in the district
- Absence of subsequent internal collapse may stop upward growth and prevent downward displacement of the mineralization.

## Hack 2 Pipe



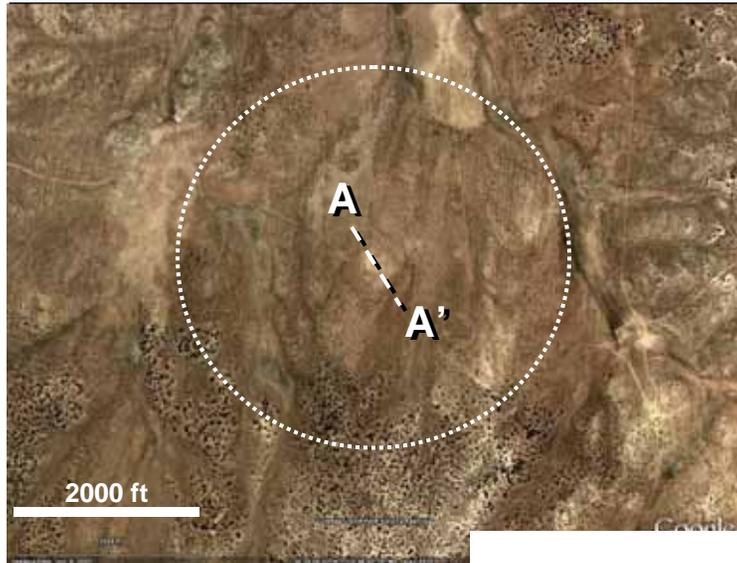
- Unbrecciated upper Kaibab outcropping at surface.
- Located within a mile wide area of evaporite-depleted Toroweap and Kaibab section.

## A Blind Breccia Pipe

- Discovered in 1979 by Western Nuclear.
- Fe staining in Coconino and altered Hermit shale in Hack Canyon.
- Alteration including secondary gypsum and other sulfates at Coconino/Hermit contact.



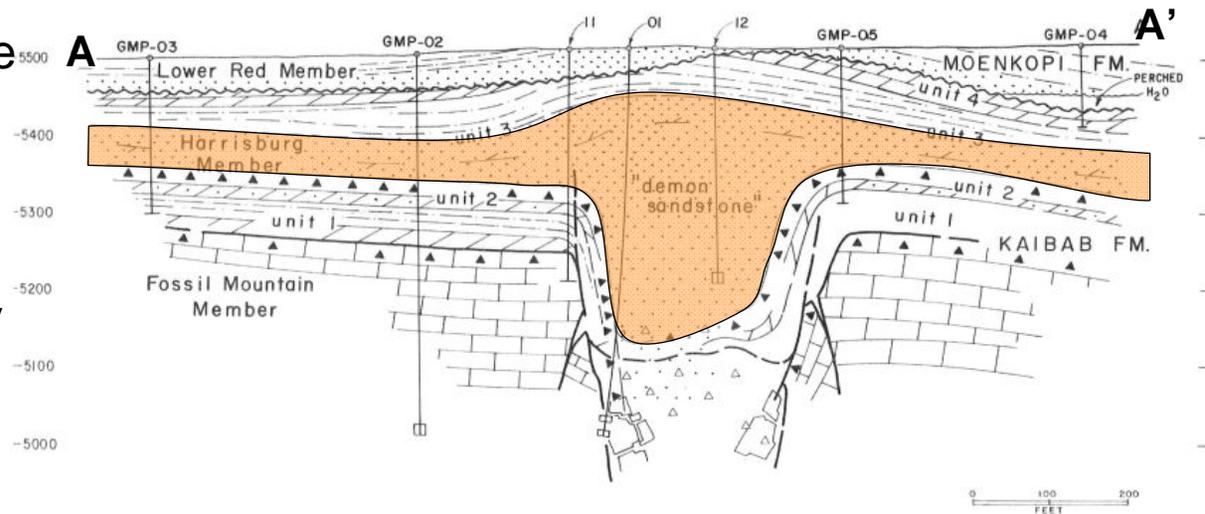
# Gump Pipe



## *Well defined and dated upper limit of stoping*

- 4000 ft diameter collapse cone
- Pipe throat did not reach the surface.
- Stopping terminated in late Permian.
- Bimodal sandstone filled pipe throat prior to evaporite dissolution

- Dome centered over the pipe throat
- Drilled to a depth of 2240 feet
- Pipe in pipe (secondary collapse) scattered U mineralization to TD

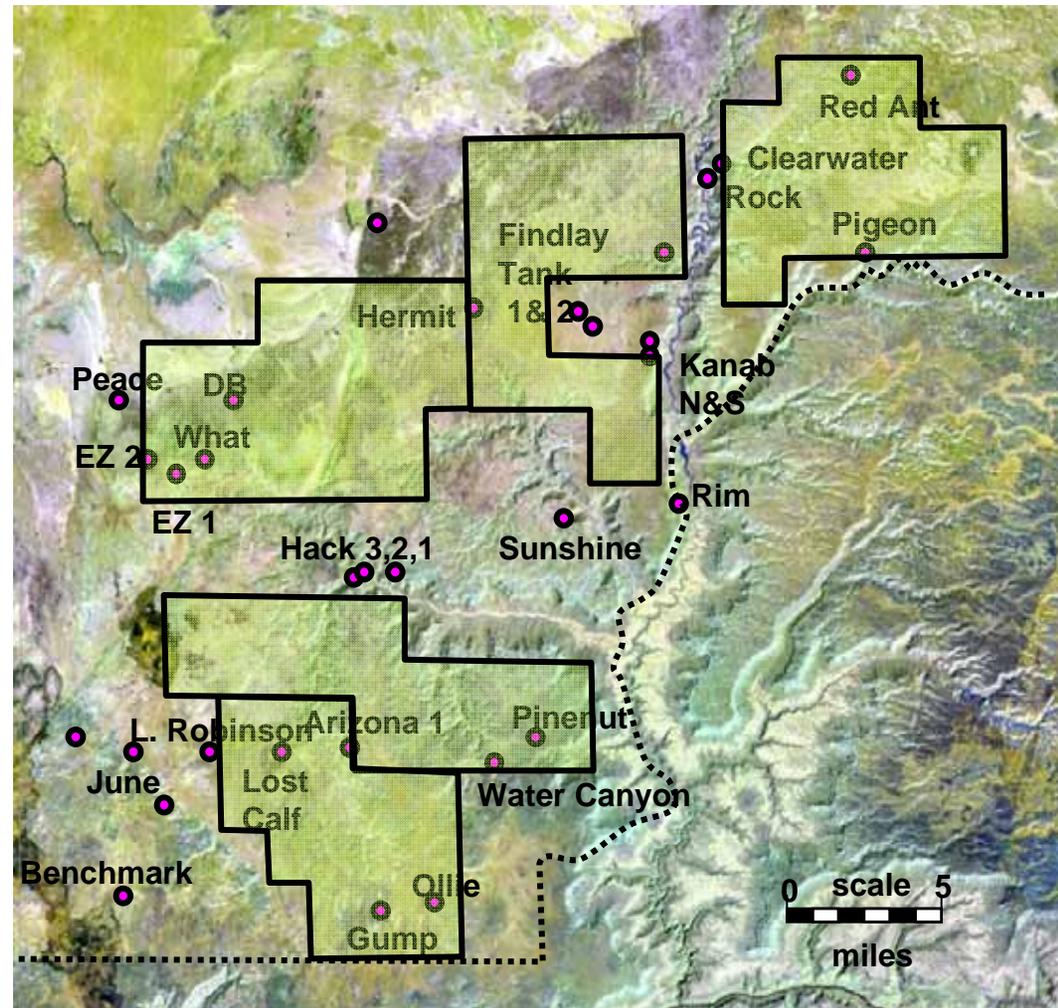


# Arizona Strip Airborne VTEM Survey

## Exploring for Blind Pipes

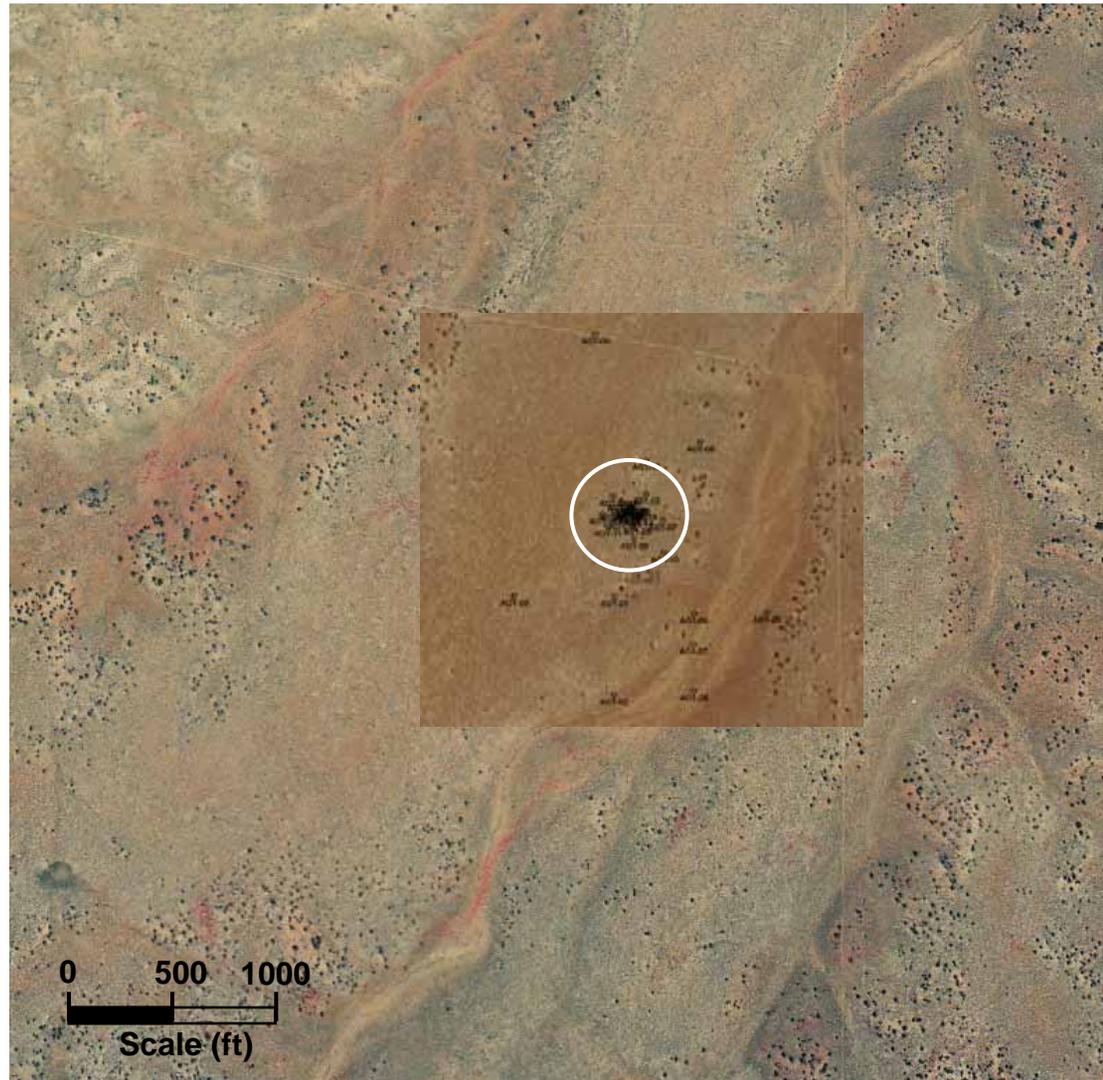
**First extensive test of airborne time domain EM on the Strip**

- Geotech Airborne surveyed 422 square miles
- 150 m line spacing
- 30 m AGL
- Most known pipes detected
- > 200 high to mod. priority anomalies with similar signatures



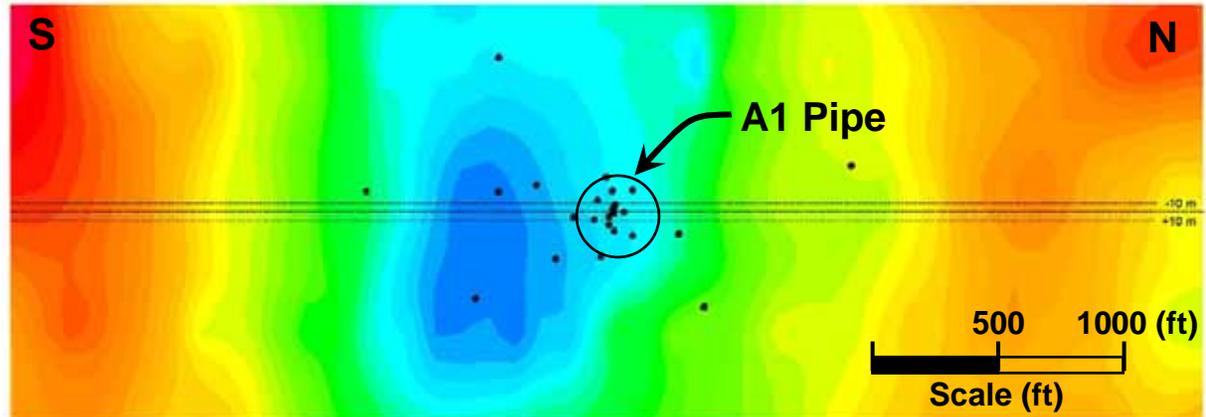
## A-1 Anomaly

- Beautiful geophysical anomaly at A-1 but no collapse cone or throat visible at the surface
- First shallow drill hole encountered 15 ft of massive gypsum in upper Toroweap section.
- Subsequent drilling defined a blind pipe 500 ft to the north

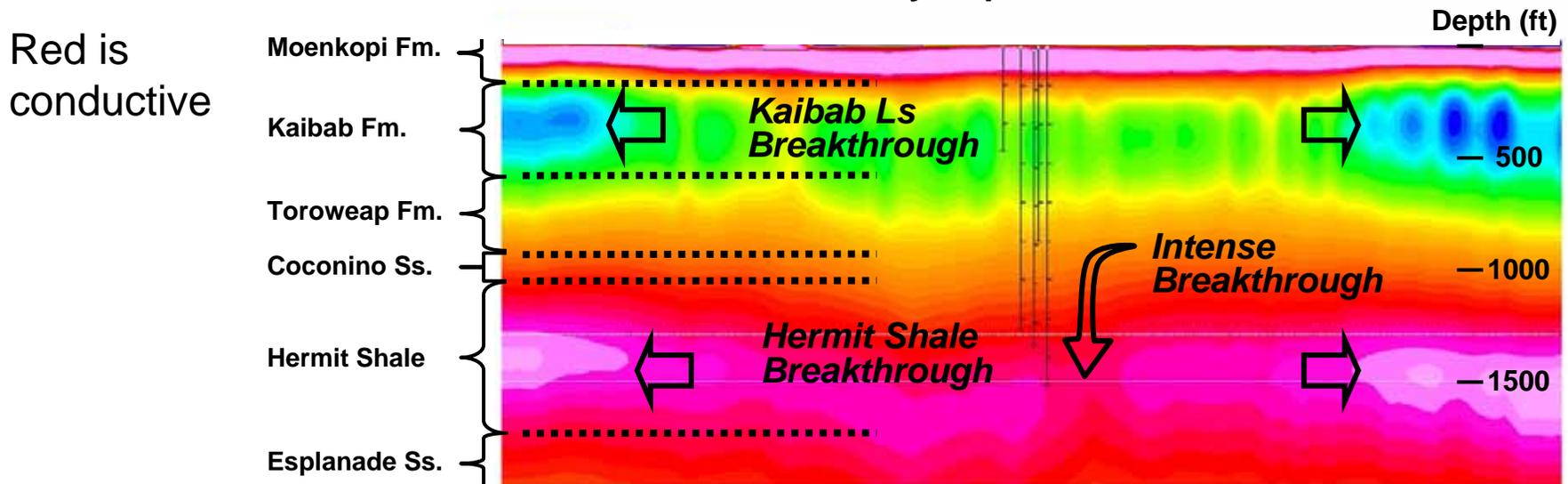


# A-1 VTEM Response – Plan and Section

Inversions and depth slices by Condor Consulting, Denver Colorado using the raw VTEM data



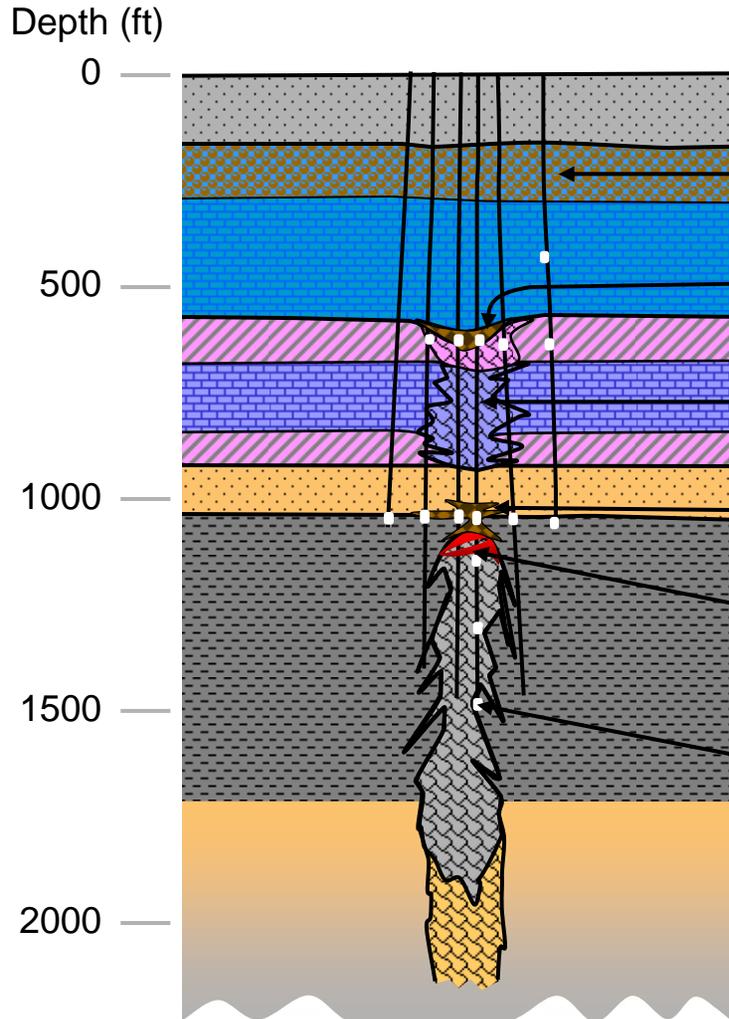
Conductivity Depth Slice 1217-1414 ft



Red is  
conductive

2D Conductivity Section

# A-1 Pipe



## A New Blind Pipe

No structure within 500 ft of the surface-undepleted evaporite section in the Harrisburg

Sulfides cementing small clast ls dominant bx at base of Pkfm.

Small clast dissolution breccia in Toroweap.

Disseminated sulfides near Pc/Ph contact above the pipe throat.

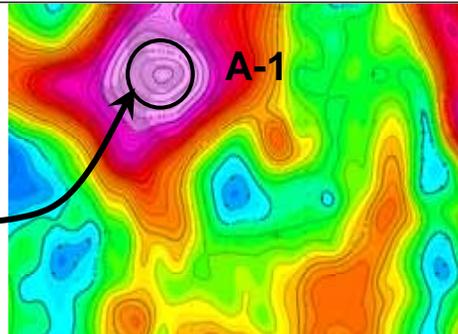
Hole A1-31 intercepted 28' av. 0.58% eU3O8 at 1046' and 4' av. 0.45% at 1119' in upper Hermit

Hole A1-30 still in large clast Hermit dominant breccia at 1500'

No secondary pipe in pipe structure evident

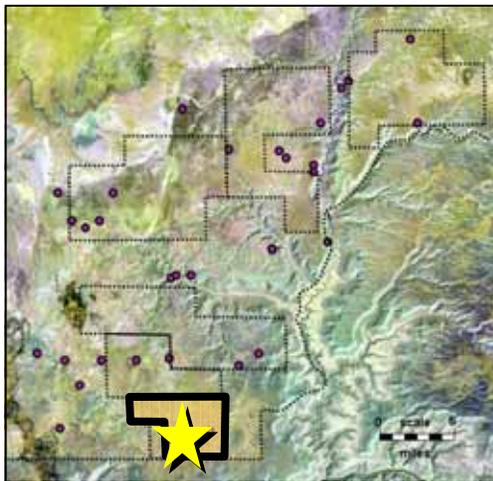
## Breccia Pipe VTEM Response 150usec Conductivity

- 2 known pipes: Gump and Ollie
- A-1 blind breccia pipe discovered on first VTEM anomaly drilled (First new mineralized breccia pipe identified in 18 yrs)



- Drilling at A-18 and A-21 defined probable pipe structures with up to 40 ft of closure in the upper Kaibab horizon.

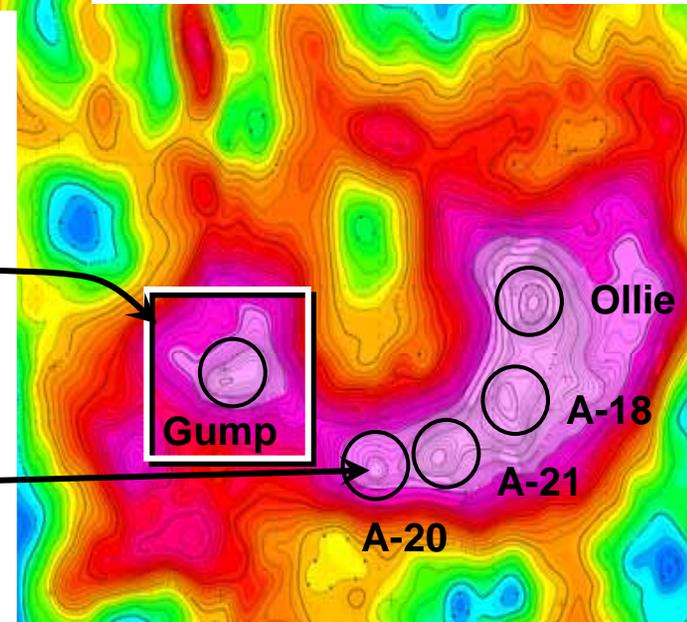
**SURVEY LOCATION MAP**



**Gump Model Area**  
Condor depth slices

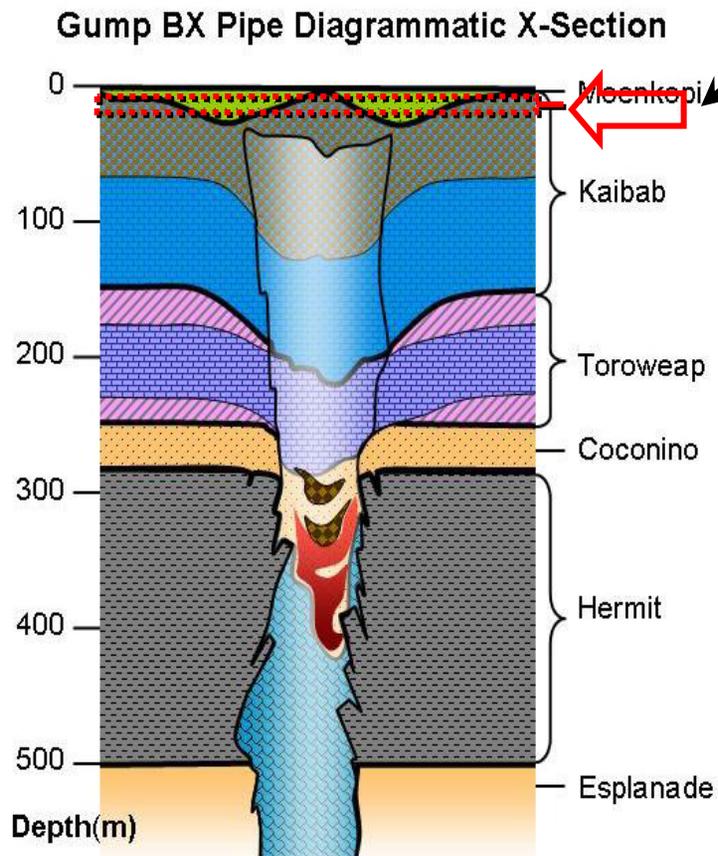
Mineralized pipe discovered at A-20 second VTEM anomaly drilled

A-20-1: 34.5 ft @ 0.37%  
incl. 6.5 ft @ 0.63% U<sub>3</sub>O<sub>8</sub>

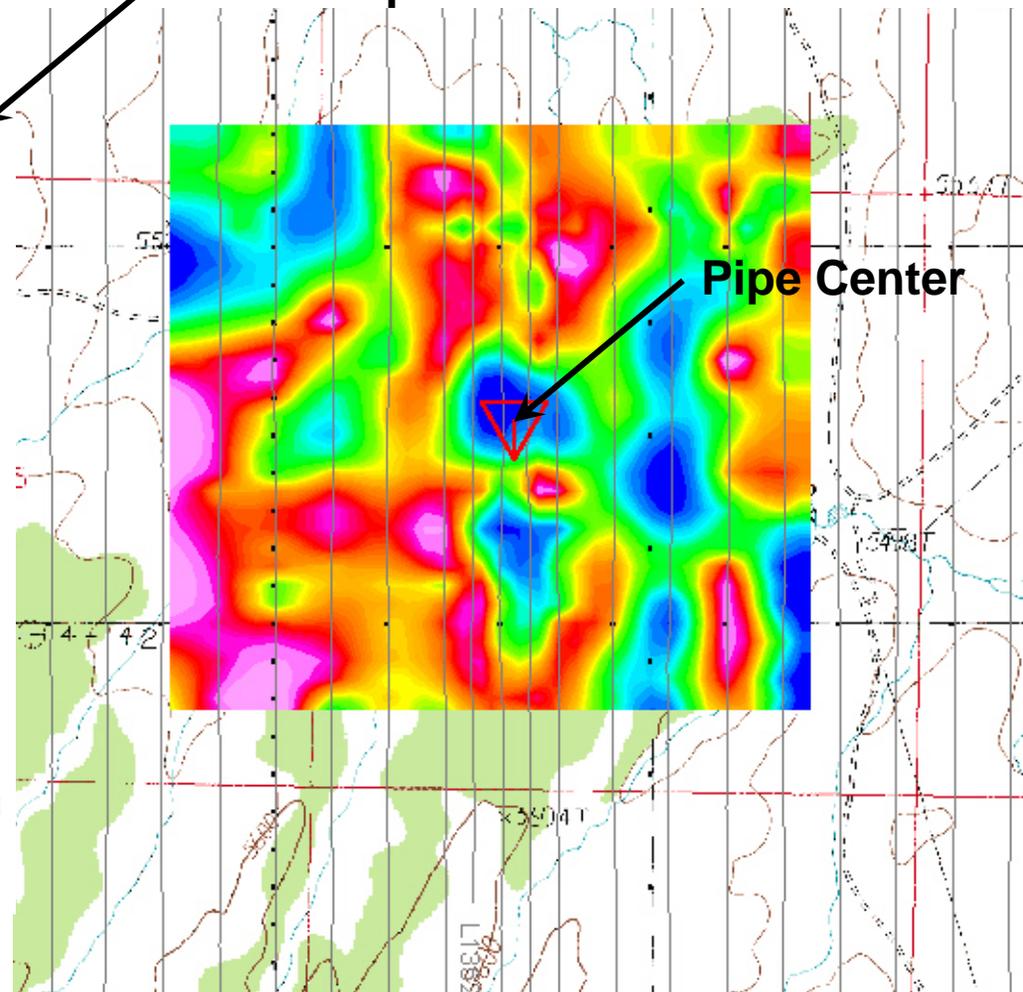


# AIRBORNE VTEM SURVEY – Gump Model 17-25 m

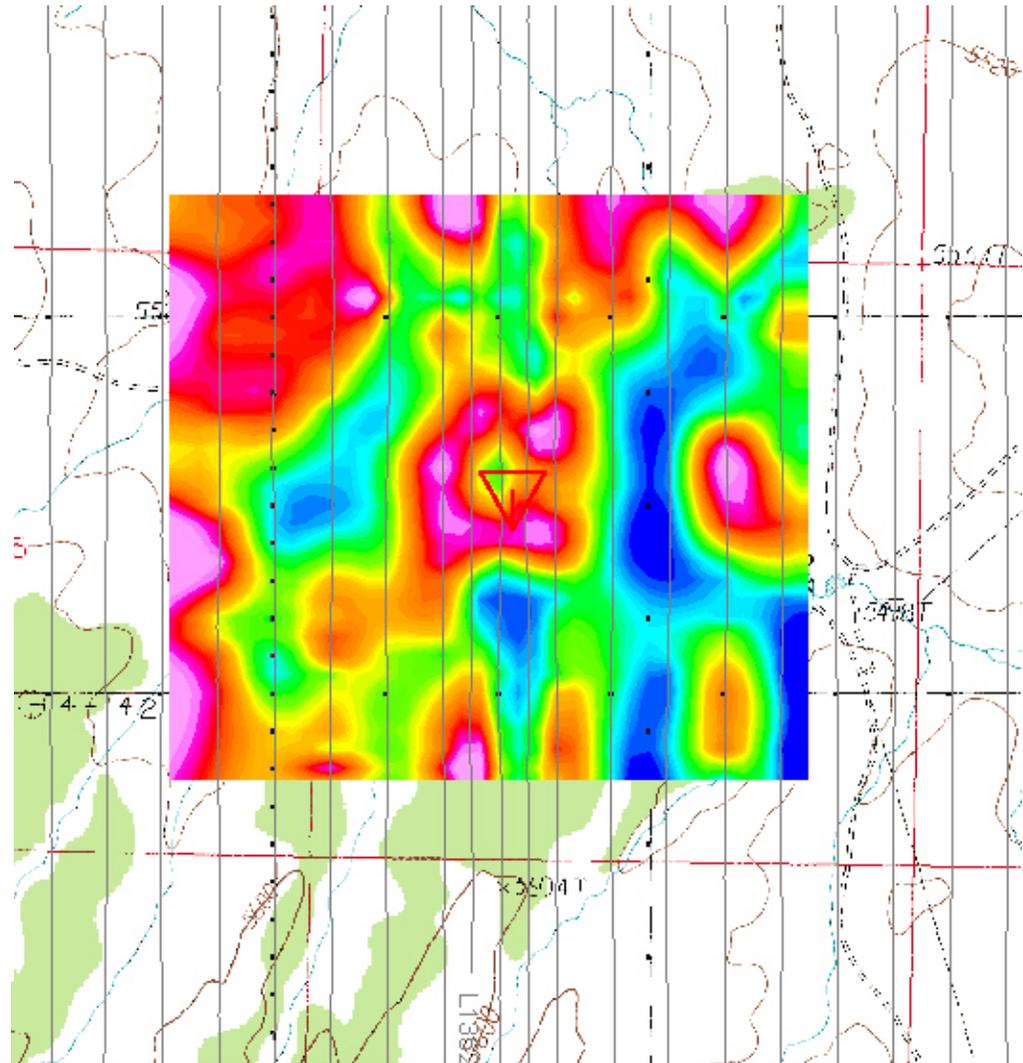
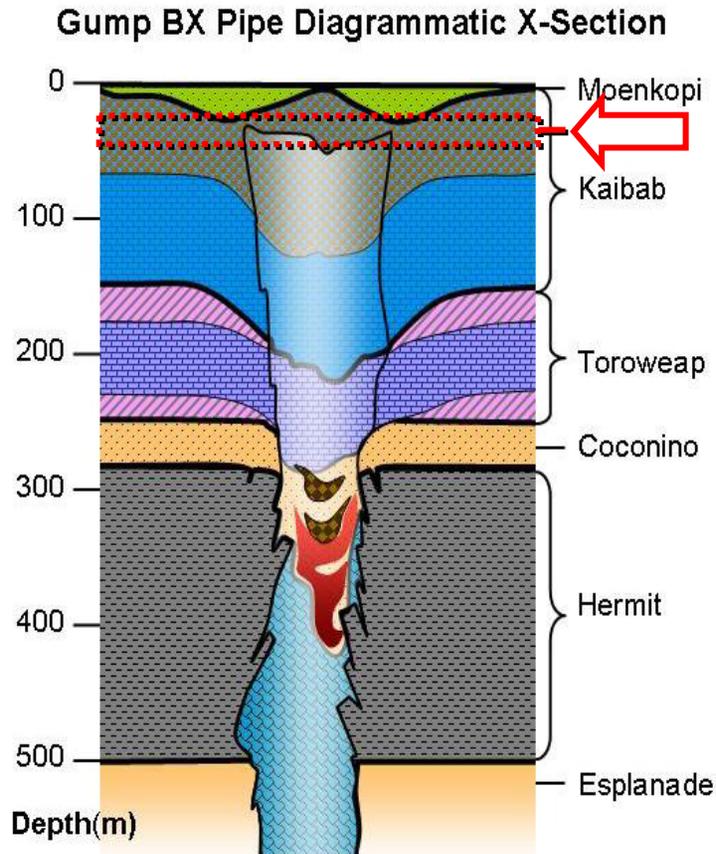
All depths in meters



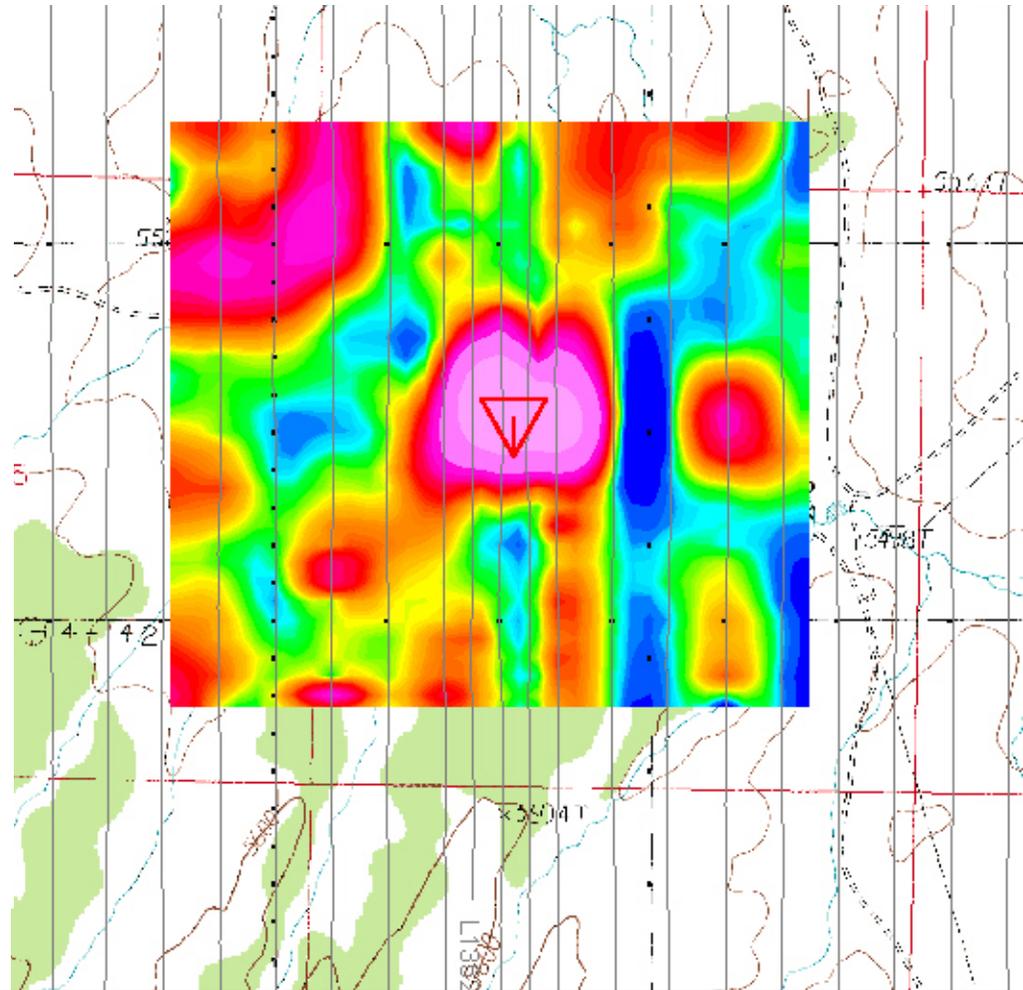
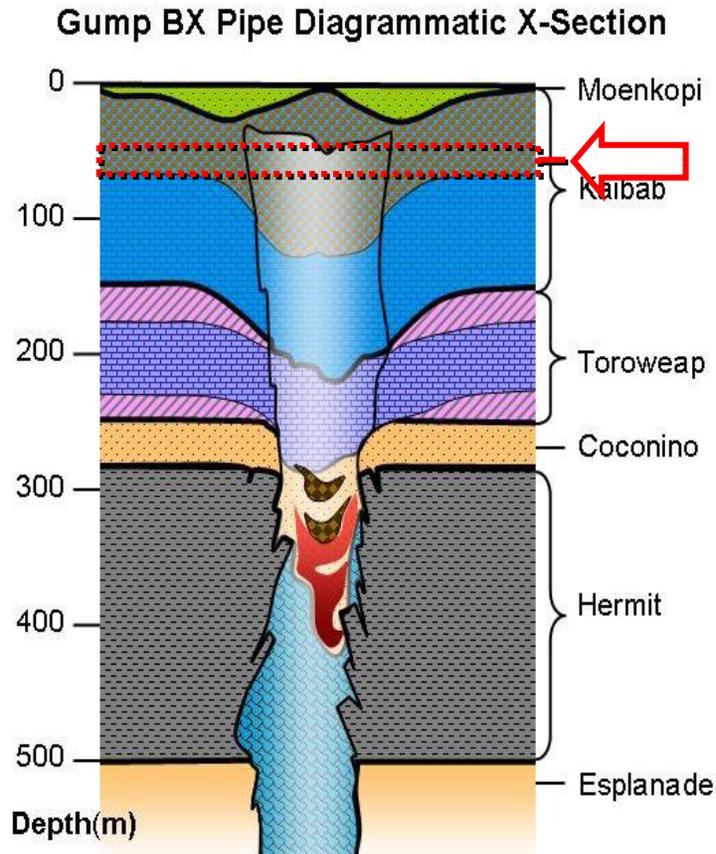
Watch Depth Arrow



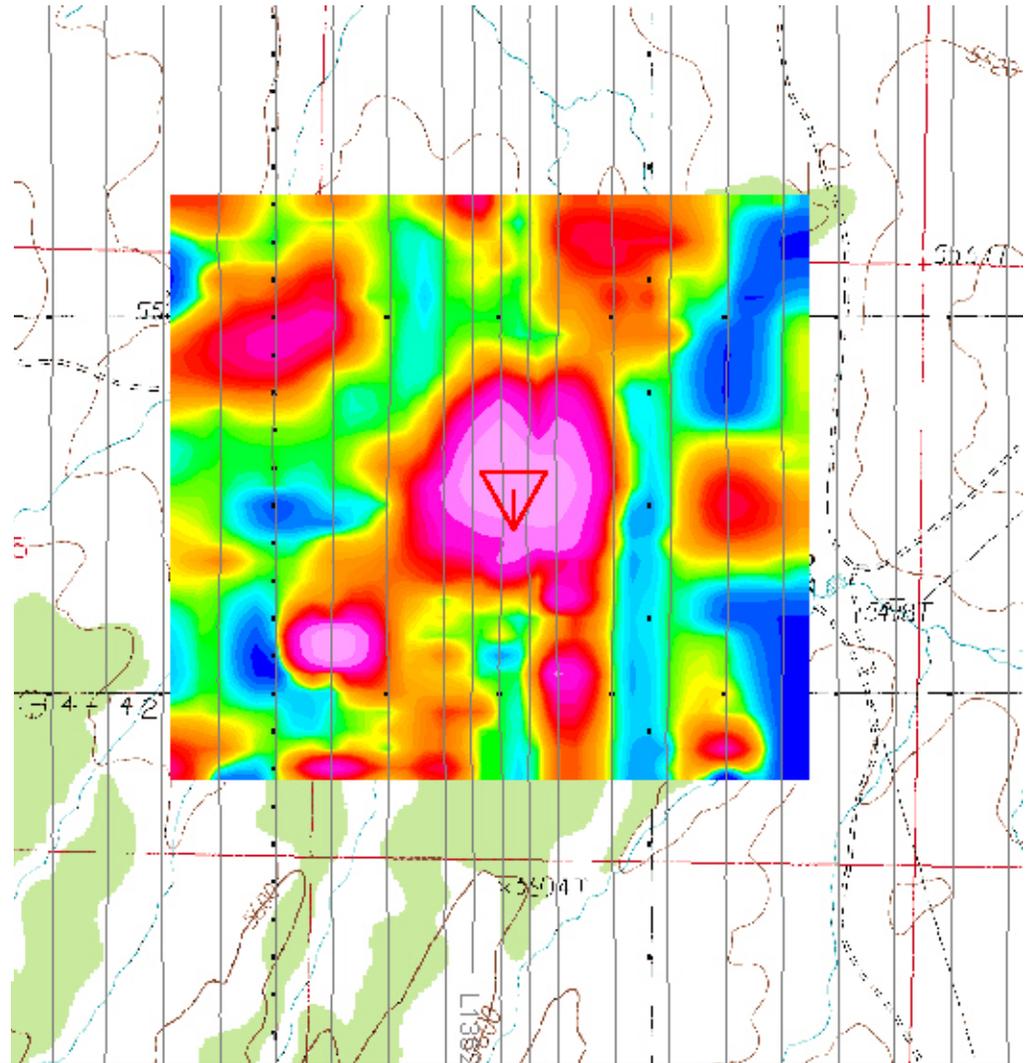
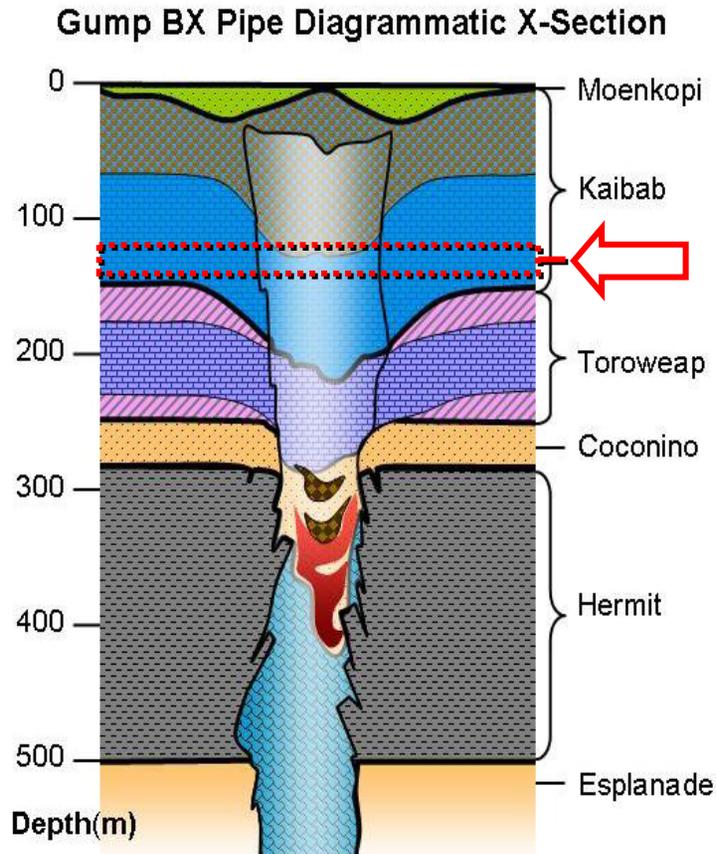
# AIRBORNE VTEM SURVEY – Gump Model 25-34 m



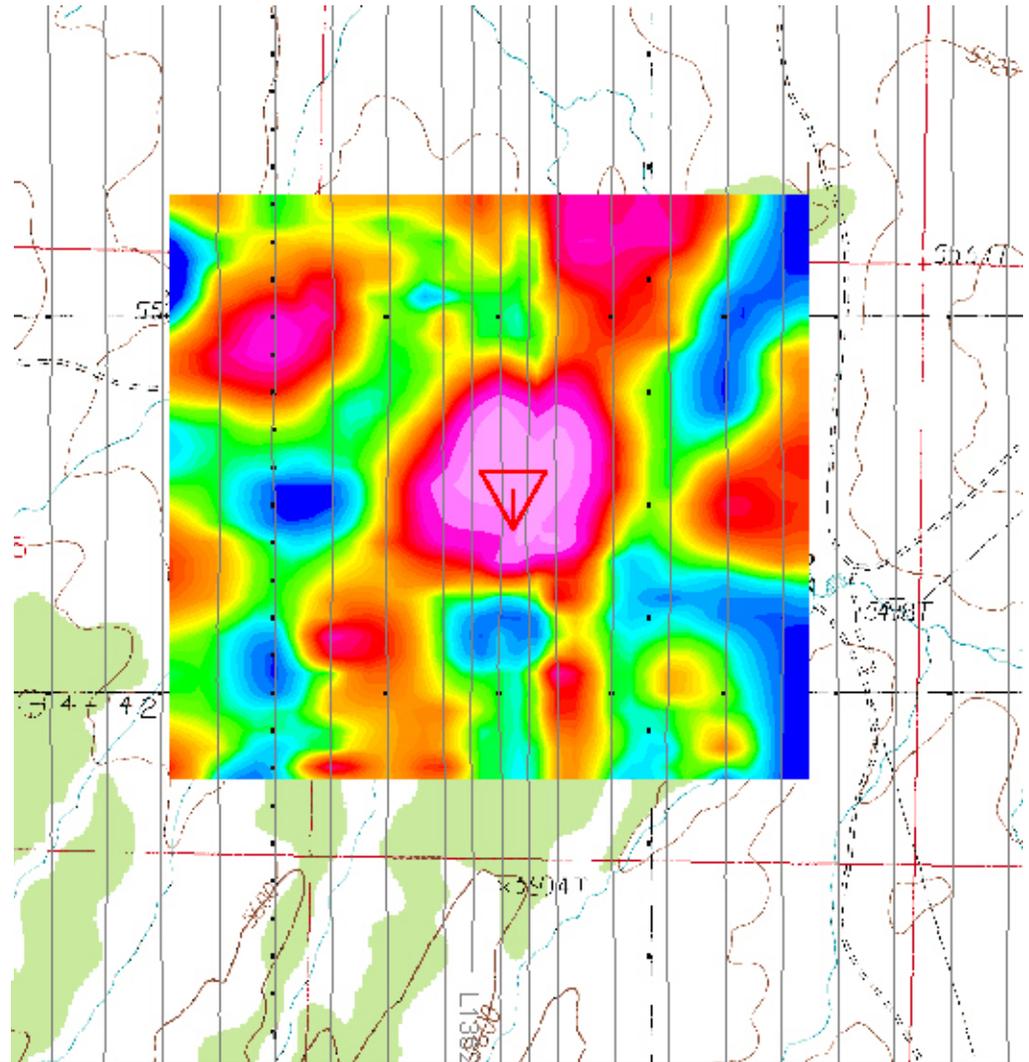
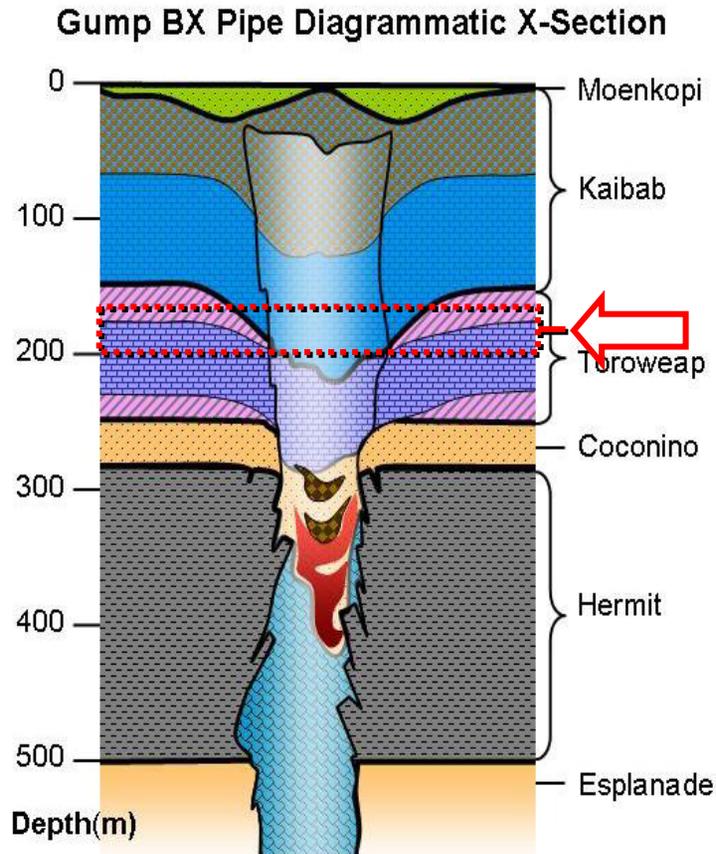
# AIRBORNE VTEM SURVEY – Gump Model 55-68 m



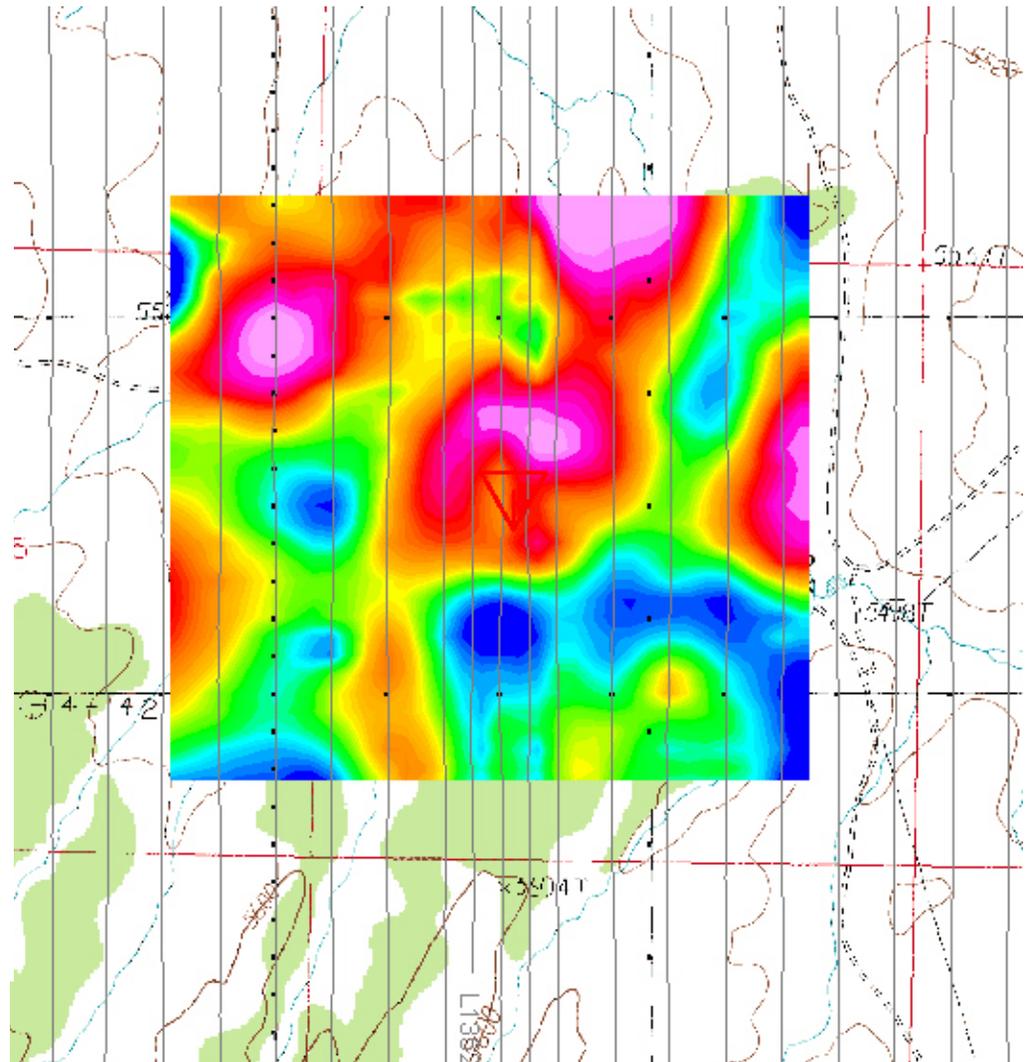
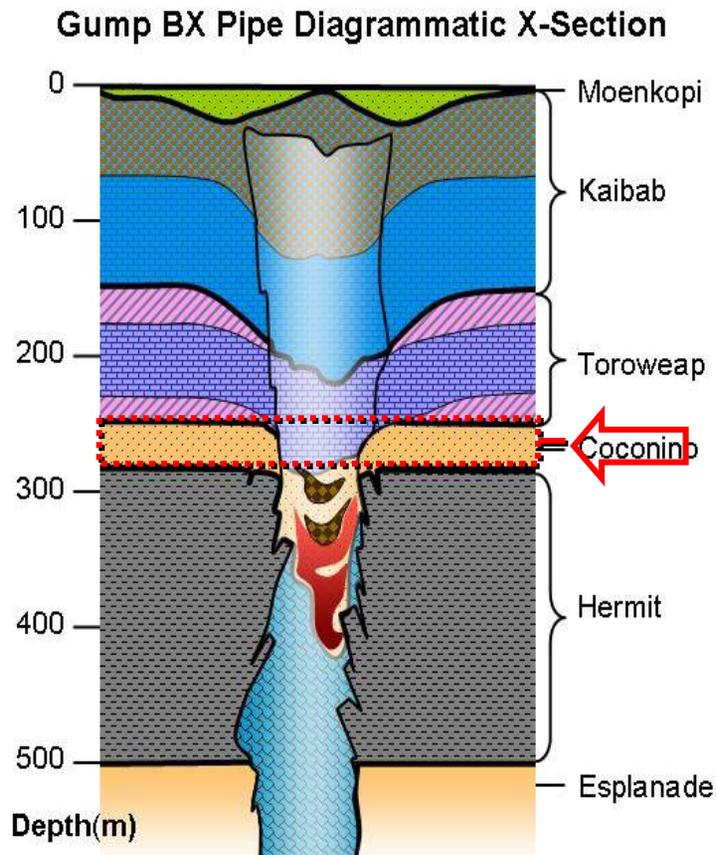
# AIRBORNE VTEM SURVEY – Gump Model 120-143 m



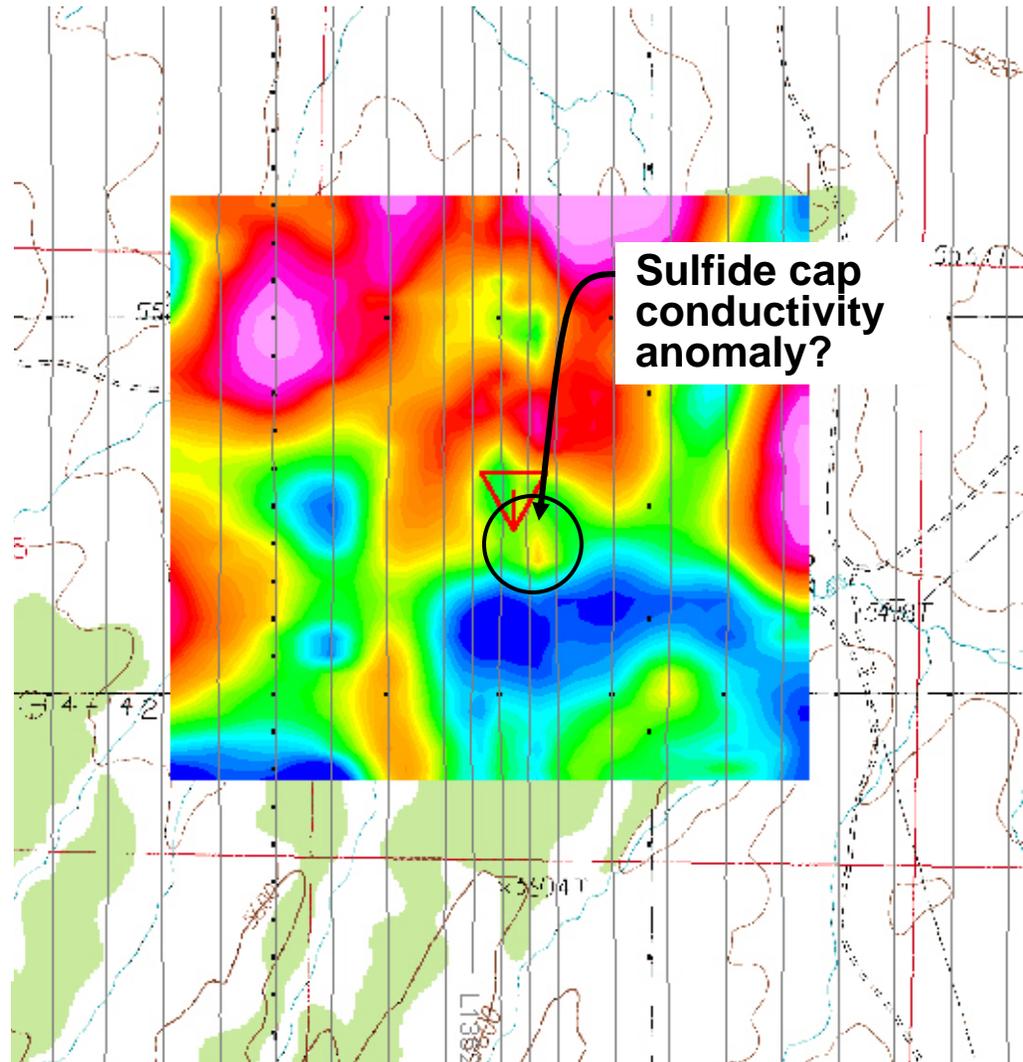
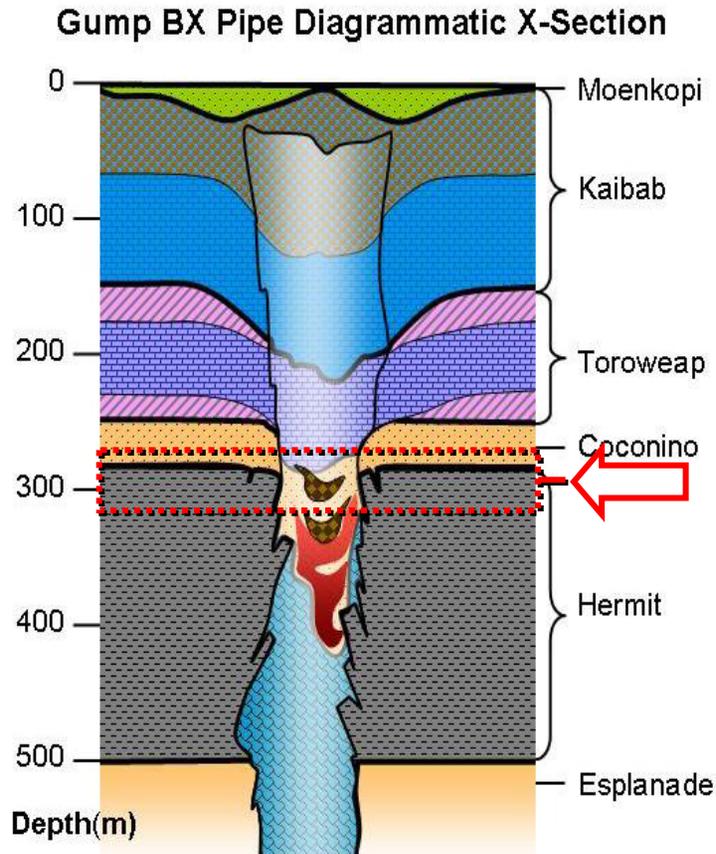
# AIRBORNE VTEM SURVEY – Gump Model 169-199 m



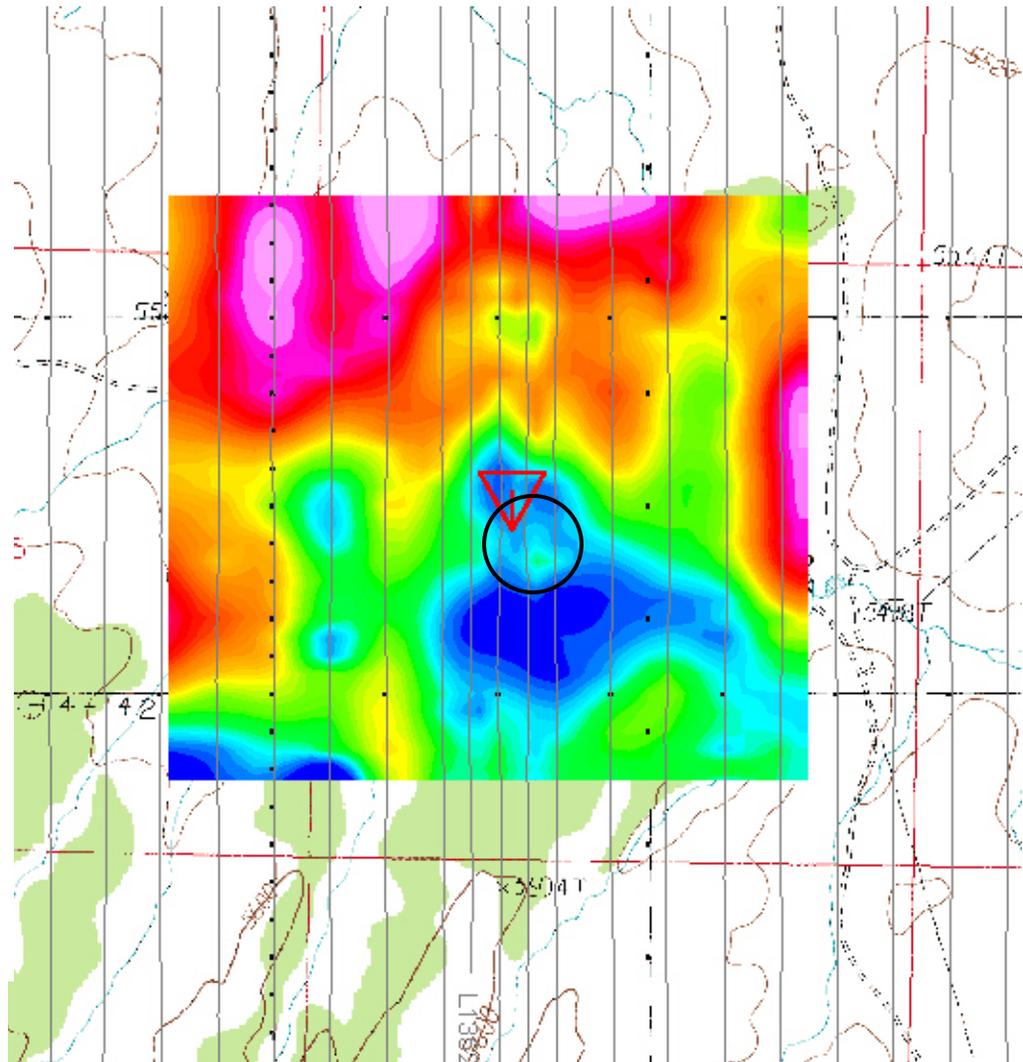
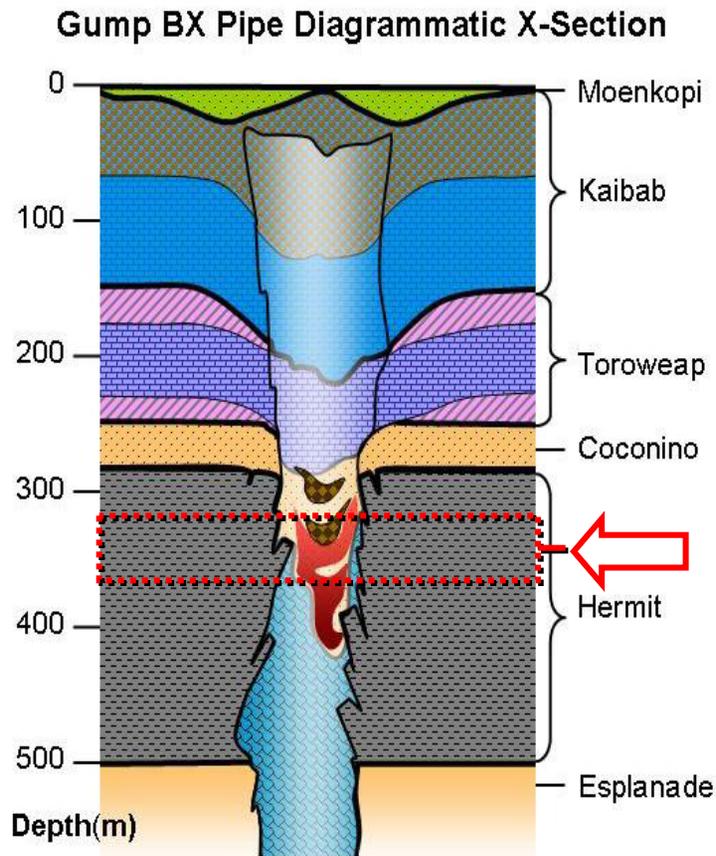
# AIRBORNE VTEM SURVEY – Gump Model 243-273 m



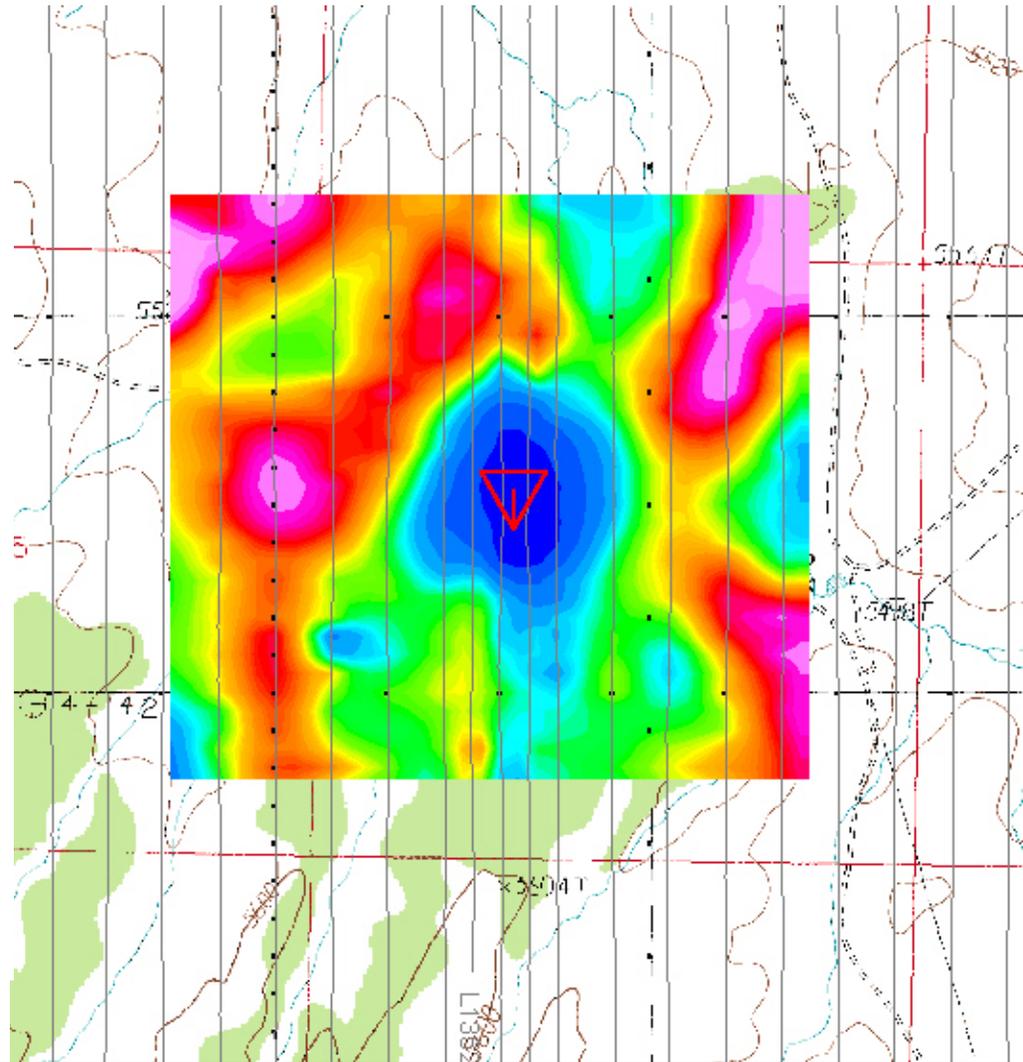
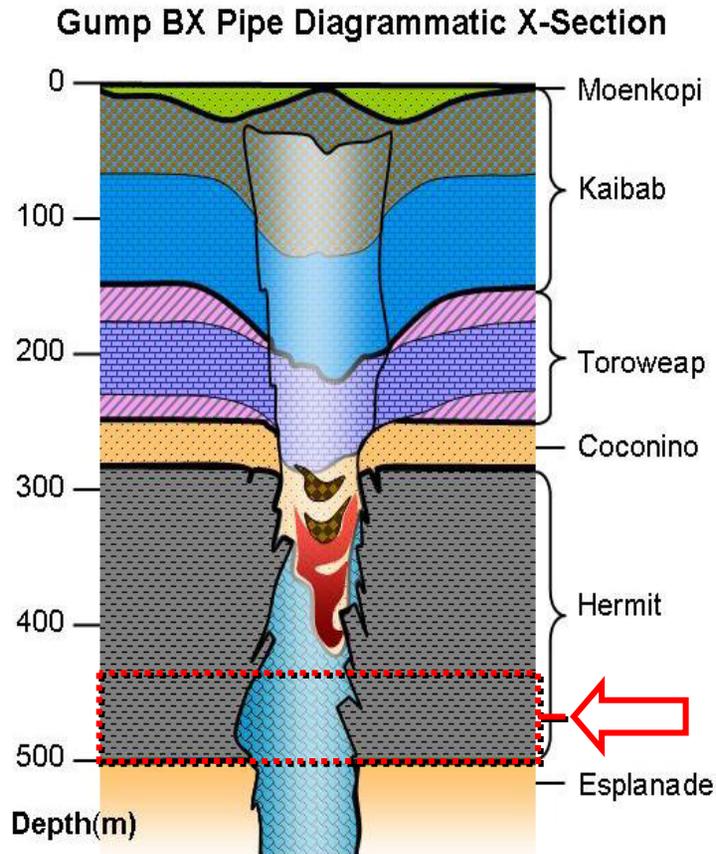
# AIRBORNE VTEM SURVEY – Gump Model 273-319



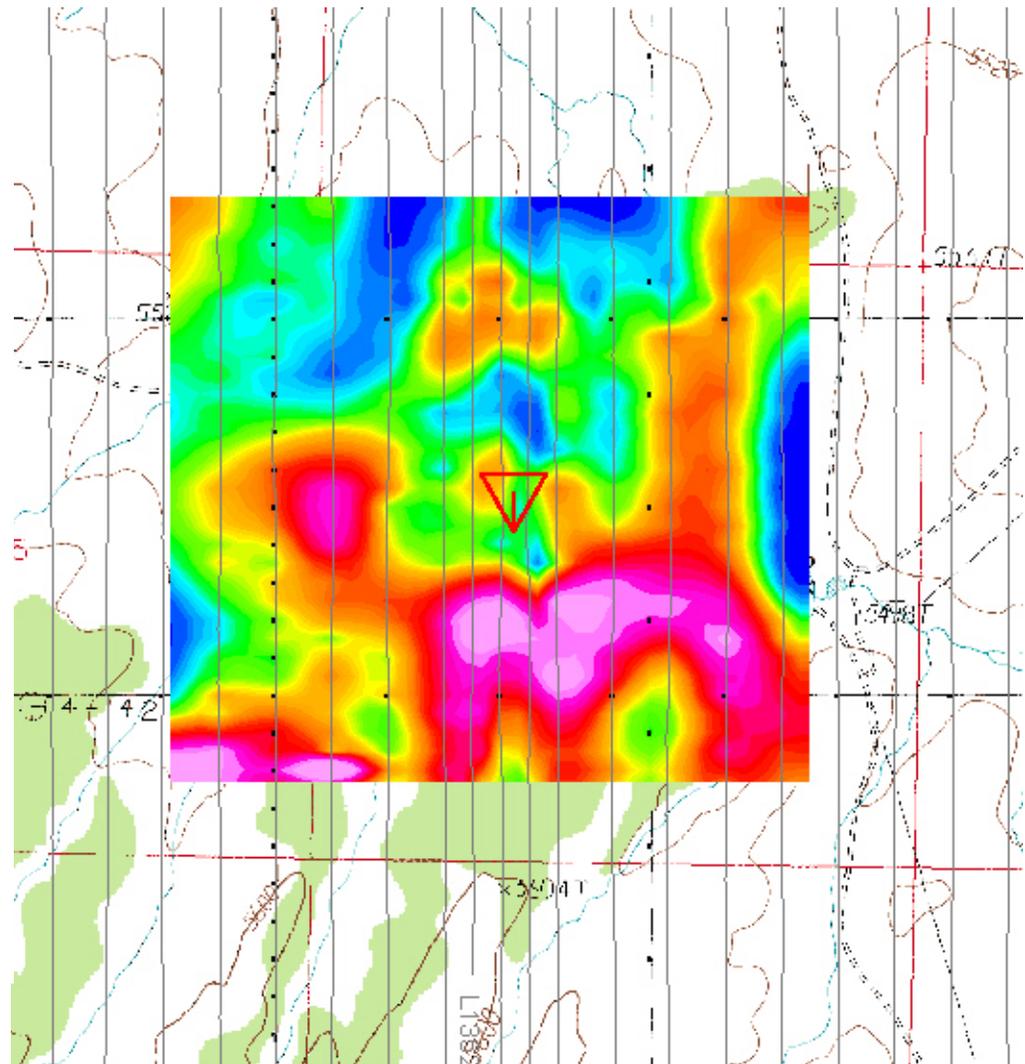
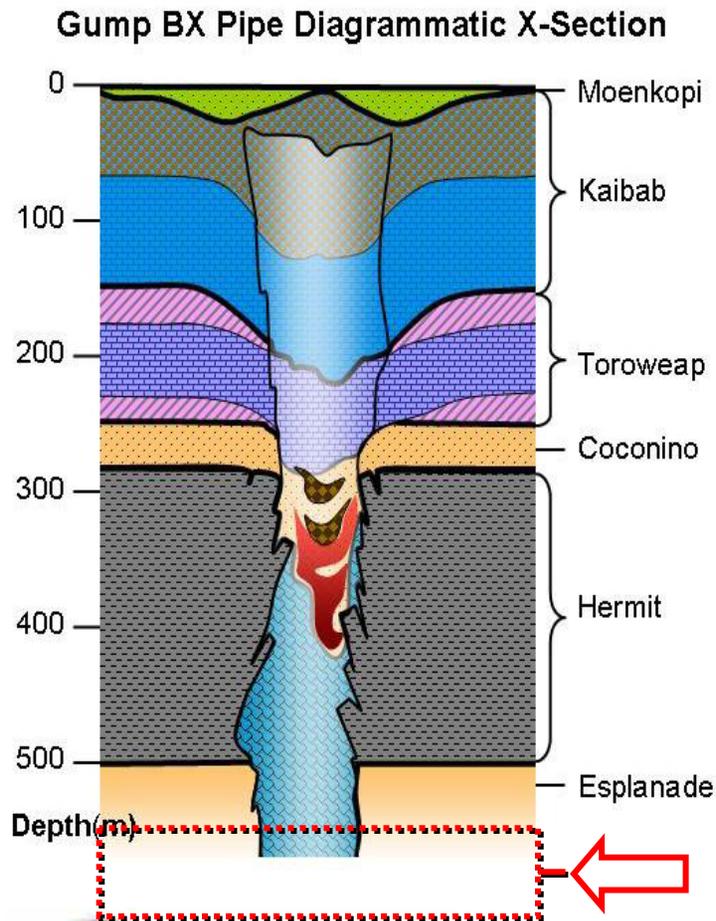
# AIRBORNE VTEM SURVEY – Gump Model 319-371 m



# AIRBORNE VTEM SURVEY – Gump Model 431-500 m

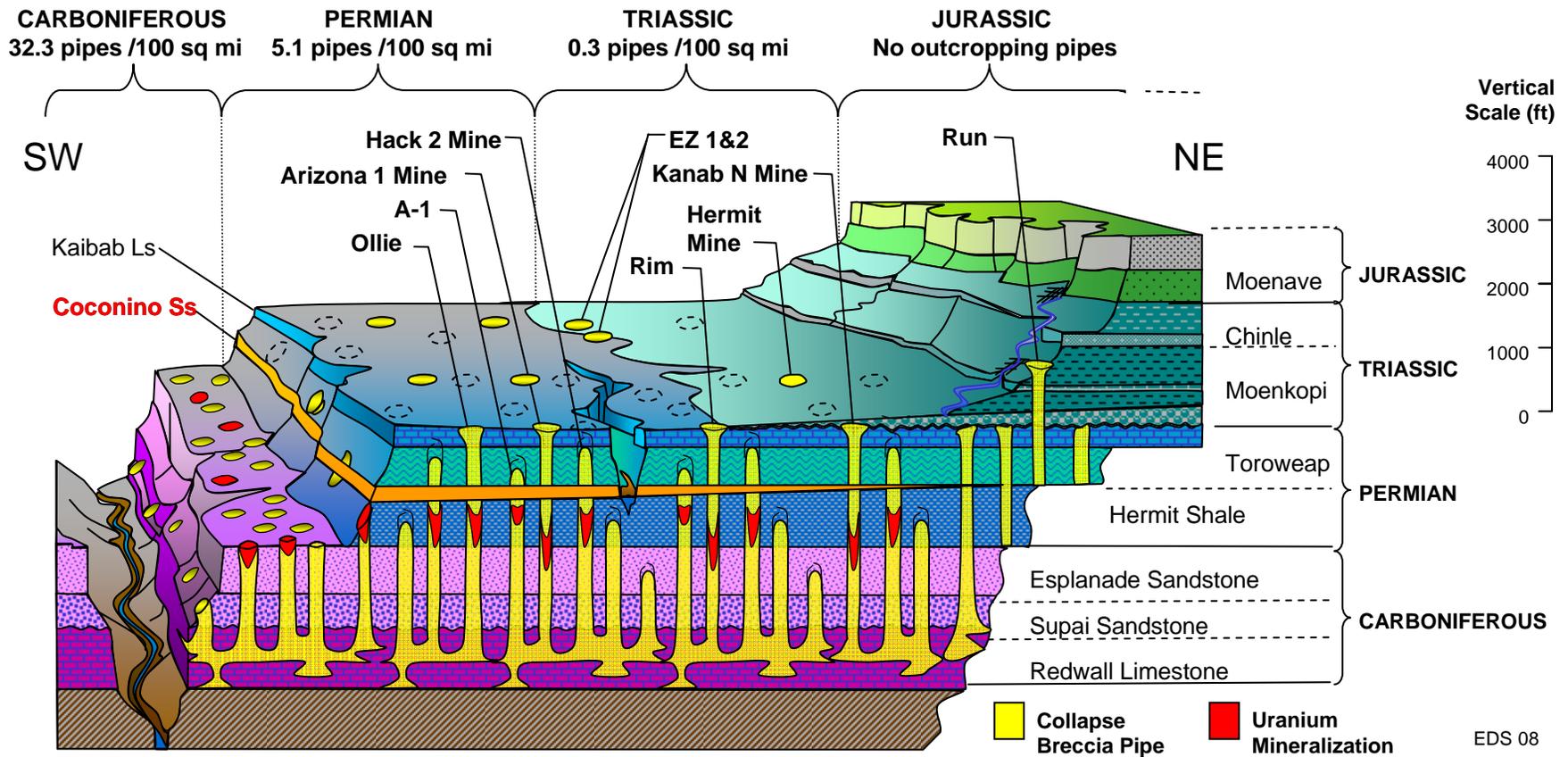


# AIRBORNE VTEM SURVEY – Gump Model 580-673 m

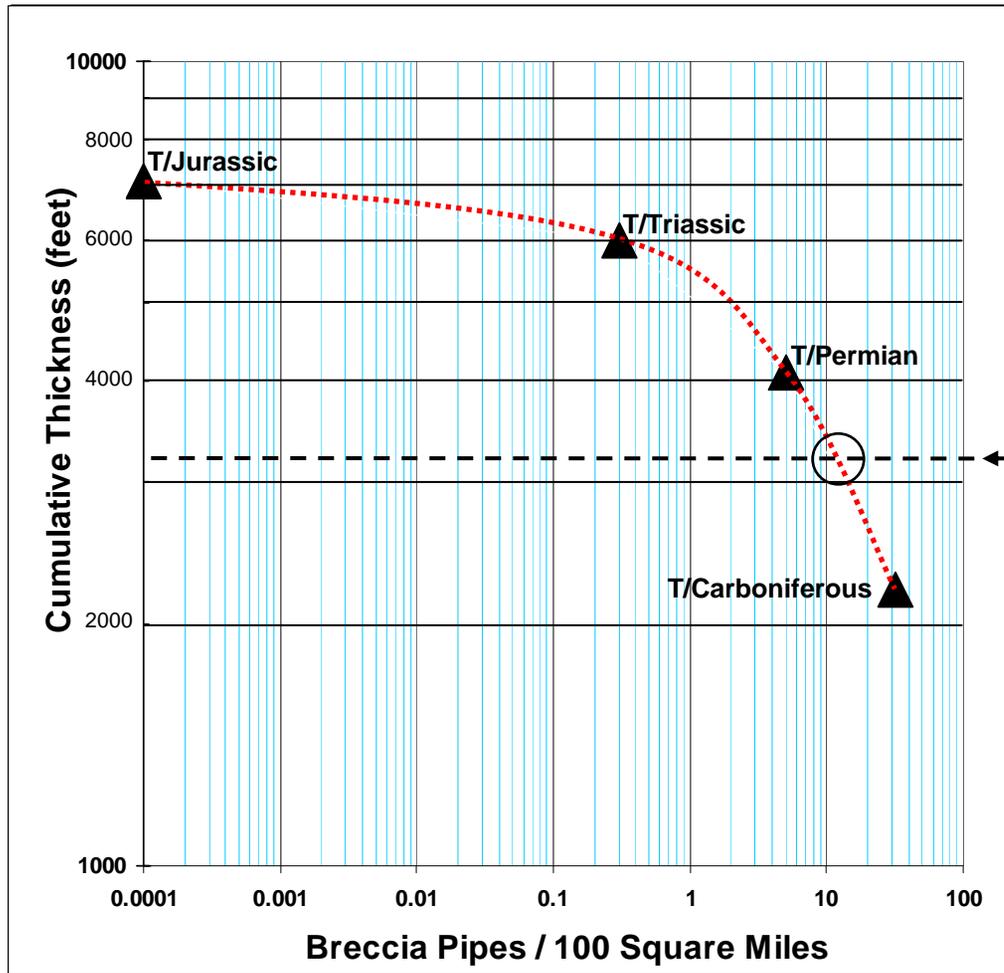


# Breccia Pipe Density

The USGS Open File Report (OFR-89-550) shows the mapped locations of 1,296 pipes in the Grand Canyon region



# Breccia Pipe Density Log-Log Plot



**How many mineralized pipes in the N district?**

**What is the potential of the N district?**

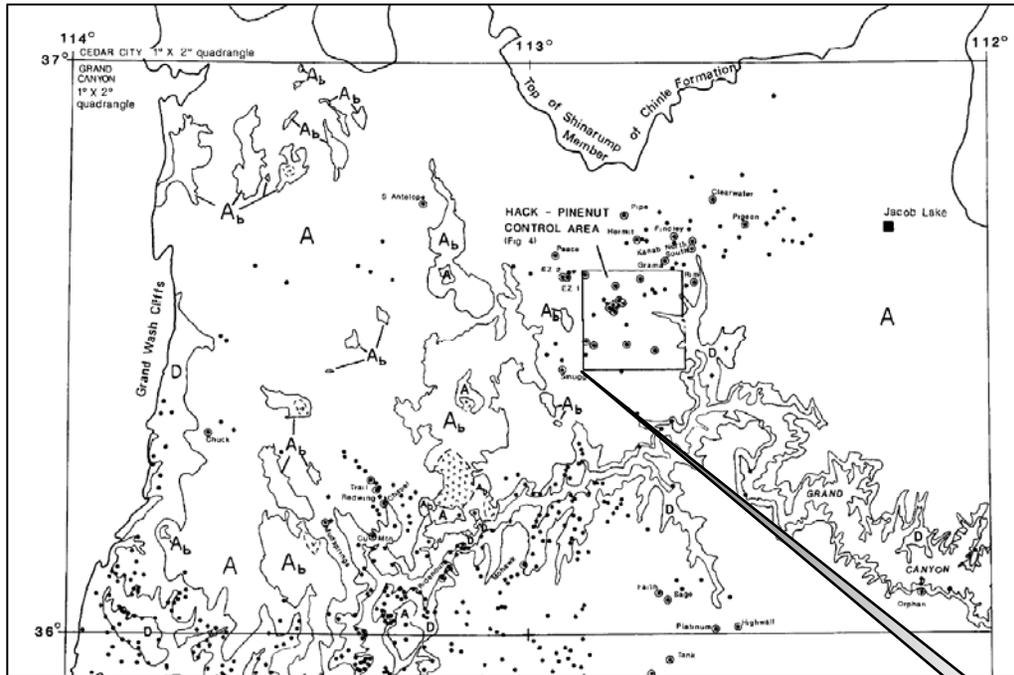
@ 3,200 feet of sedimentary cover (Lower Toroweap horizon) ~ 12 pipes per 100 square miles

1000 square miles in the northern district X 12 pipes/100mi<sup>2</sup>= **120 pipes**

120 pipes X 1.8 million lbs/pipe = **216 million lbs**

**= 108 tons U3O8/sq. mile**

# USGS AZ Strip Uranium Endowment Estimate (Circular 1051)



Based on the Hack–Pinenut Control Area, favorable Areas A and “Ab” were given a calculated mean endowment of **112.4 tons** U<sub>3</sub>O<sub>8</sub> per square mile.

- All of the northern district is included in this category
- The same endowment was given to the southern Arizona Strip district.

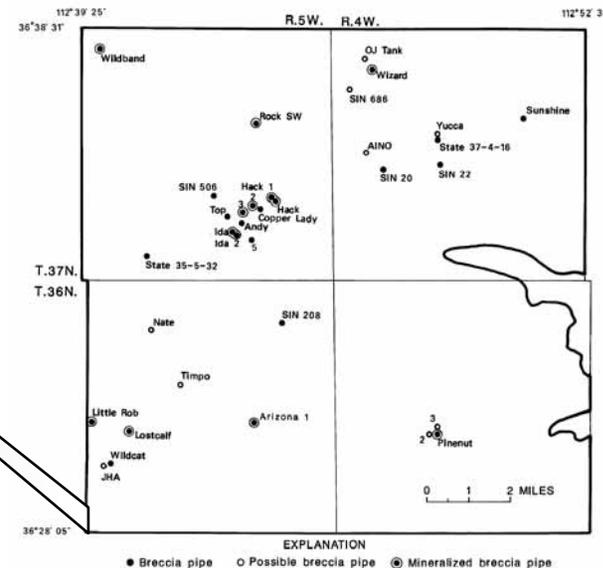


Figure 4. Map of the Hack-Pinenut control area for uranium-bearing collapse-breccia pipes in northern Arizona. See figure 2A for the location in the Grand Canyon 1°x2° quadrangle.

From: US Geological survey Circular 1051; The 1987 Estimate of Undiscovered Uranium Endowment in the Solution-Collapse Breccia Pipes in the Grand Canyon Region of Northern Arizona and Adjacent Utah

## A New Phase of Exploration in a Mature District



### ***Conclusions***

- Airborne VTEM has identified most known pipes and 200 high and moderate priority conductive anomalies with a similar geophysical response
- Many of these anomalies could be blind pipes
- If just ½ of the anomalies are mineralized pipes, the northern district could attain the USGS endowment estimate of 112.4 tons / sq. mile
- Although individually pipes are small deposits, collectively they may represent more than 200 million lbs U3O8 in the northern district alone
- The southern district could have a similar endowment
- A single mine can produce from several pipes and collectively, the breccia pipes of northern Arizona Strip could achieve a “large” deposit status on a world scale.
- High Grades , no ground water, excellent rock conditions and “cookie cutter” permitting, mine design and development may also rank the Arizona breccia pipes among some of the world’s most economical ore deposits.

## ***ACKNOWLEDGMENTS***

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**Management and Shareholders of Quaterra Resources**



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**Logging - Strata Data Inc., Casper WY**

**Airborne Geophysics - Geotech Ltd., Aurora, ON**

**Data Processing – Condor Consulting, Denver, CO**

**Staking - All Points North, Elko NV and Kenny Redd, Kanab, UT**

**Borehole and surface TEM - Zonge Engineering, Tucson, AZ**

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