

# Evaluation of potential shale-gas targets in Arizona

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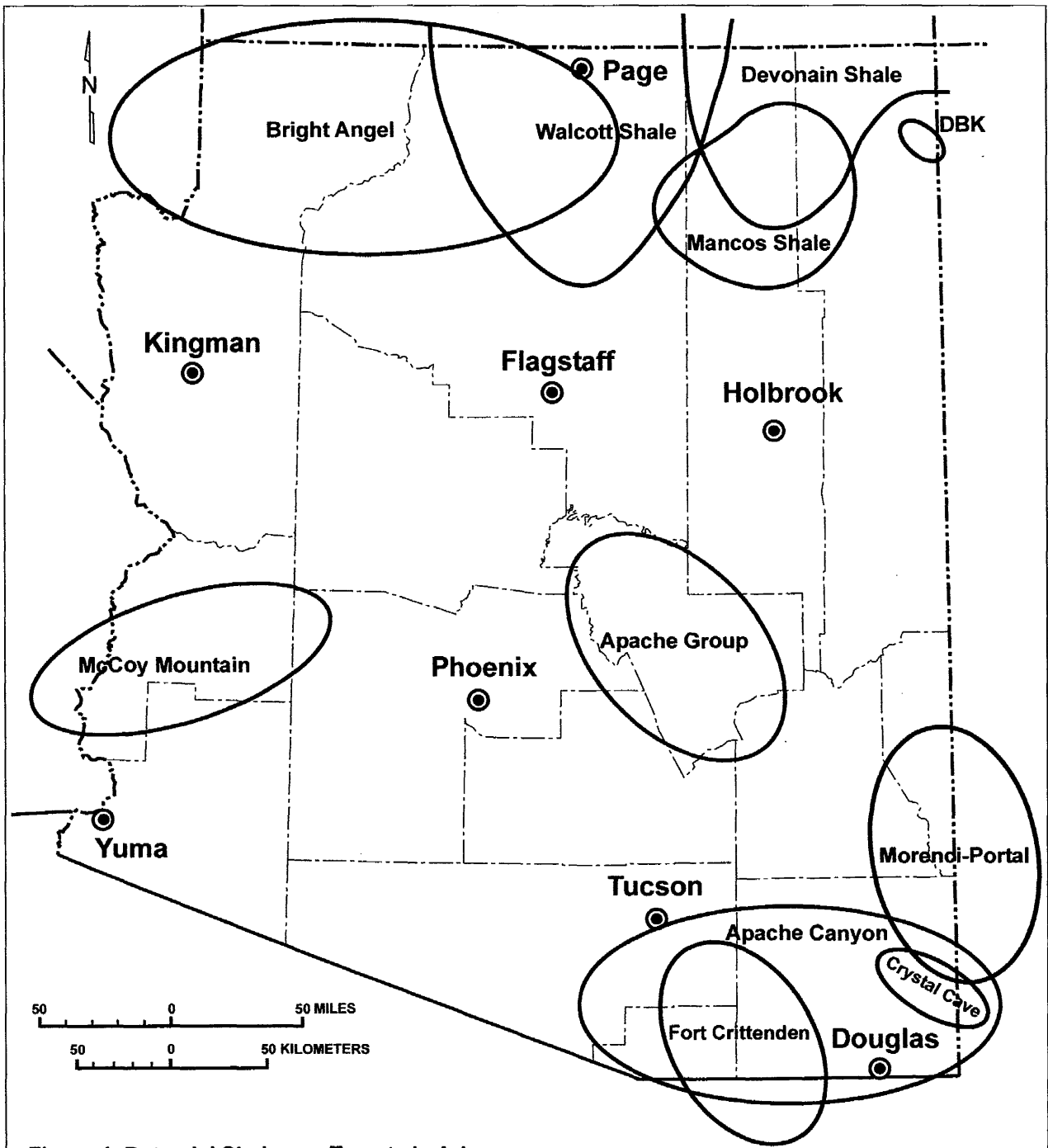
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**Note: This is the objective of a proposal that was not funded**

**I. Objective:** The objective is to complete an initial assessment of the potential of frontier shale-gas resources in Arizona and provide the results to industry through publication and presentation at a professional meeting. During Phase one we will review literature and well files and compile geochemical data and information about the extent and thickness of each potential shale-gas unit (Figure 1). During Phase two we will collect approximately 15 samples for geochemical analysis from each potential unit. Phase three will entail analysis of all samples for total organic carbon (TOC), plus Rock-Eval pyrolysis and vitrinite reflectance on samples with greater than 0.5% TOC. During phase four we will publish the results of the assessment and present the results at a professional meeting.

## Objective details: - Target shales in Arizona

Mancos shale	Upper Cretaceous	Northern Arizona	Unknown TOC, dark gray, extent is Black Mesa	
Fort Crittenden	Upper Cretaceous	Southern Arizona	Basal shale black <u>Physa</u> , unknown extent	
McCoy Mtn. Fm	Late Cretaceous	Southern Arizona	Maroon, purple, gray mudstone, poss mm	
Apache Canyon	early K	Bisbee	Southern Arizona	Thick black shale, Whetstone Sonoita area
Crystal Cave formation	Jurassic	Southern Arizona	Thick black shale, unknown extent	
DBK shale	Penn	Hermosa Group	Northern Arizona	Persistent 10 ft black shale, unknown extent
Devonian Aneth shale		Northern Arizona	Possible, Devonian production at Walker Creek	
Morenci (Portal) shale	Devonian	Southern Arizona	Equivalent to fissile black Percha shale NM	
Bright Angel shale	Cambrian	Northern Arizona	Questionable TOC, better seal than source	
Walcott shale	pC	Chuar Group	Northern Arizona	Good TOC (up to 8.29%) preserved in half graben
Pioneer shale	pC	Apache Group	Central Arizona	Limited extent



**Figure 1. Potential Shale-gas Targets in Arizona**

**Upper Cretaceous Mancos shale**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “The Mancos Shale is predominantly dark gray, bluish-weathering, siltstone and claystone.”  
(Nations and others, 2000, p. H11)

- Extends across entirety of Black Mesa in Coconino, Navajo, and Apache counties in northeastern Arizona
- The Mancos “is about 700 ft thick on the north side of Black Mesa and thins to about 475 ft in the southernmost complete exposures at Blue Point on Padilla Mesa. It continues to thin southward toward its pinch out near Show Low.” (Nations and others, 2000, p. H11)

#### **Upper Cretaceous Fort Crittenden Formation**

- No geochemical analyses, unknown total organic carbon content (TOC)
- Basal black shale, randomly spaced zones rich in black, thin-shelled Physa and fossil wood, fossiliferous mudstone records marginal lacustrine mudflat (Hayes, 1987)
- Extends across eastern Pima, Santa Cruz, and western Cochise counties in southern Arizona
- Shale member ranges up to 850 ft thick

#### **Late Jurassic - Late Cretaceous McCoy Mountain Formation**

- No geochemical analyses, unknown total organic carbon content (TOC)
- Maroon, purple, gray mudstone. “The mudstone member (900 m thick) consists of thick intervals of gray siltstone and mudstone interbedded at regular intervals with thin horizons of sandstone and conglomerate.” (Harding and Coney, 1985, p. 760). “Homogenous mudstone and siltstone interbedded with minor sandstone and conglomerate are common in the uppermost part of the unit (mudstone member).” (Tosdal and Stone, 1994, p. 478).
- Extends westward across southern La Paz County from southeast of Quartzite into California.
- Mudstone member ranges up to 2900 ft thick (Harding and Coney, 1985, p. 760)

#### **Early Cretaceous Apache Canyon/Schellenberger Formations of Bisbee Group**

- No geochemical analyses, unknown total organic carbon content (TOC)
- Thick black shale. “The Apache Canyon Formation (820-1640 ft thick) is composed dominantly of thin-bedded dark-gray to black mudstone and limestone in varying proportions. (Dickinson, Fiorillo, Hall, Monreal, Potochnik, and Swift, 1989, p. 453-454)
- Extends across most of southern Cochise County in southeastern Arizona but primarily Whetstone Mountains and Sonoita areas
- Ranges from 820-1640 ft thick across the area with 1000 ft of dark to black shale in the Mountain States 1A well in 29-19s-18e.

### **Middle-Late Jurassic Crystal Cave Formation**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “Dominant lithic type is black to dark-gray siltstone and mudstone with a blocky character, generally lacking in fissility...Plant fragments are common...black mudstones represent anoxic deposition...” (Lawton and Olmstead, 1995, p. 27 and 32)
- Extends northwest-southeast across Chiricahua Mountains between Portal and Douglas in eastern Cochise County.
- Partial measured section of 475 ft

### **Pennsylvanian DBK shale in Hermosa Group**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “The top of the lower member is a persistent 10 ft bed of black carbonaceous shale” (Mc Kenny and Masters, 1968, p. 2047)
- Present in Dineh-bi-Keyah field and may be source bed for oil accumulation in igneous reservoir rock of Oligocene age. May extend across northern extent of Defiance uplift in northern Apache County.
- Ten ft thick at Dineh-bi-Keyah field

### **Devonian Elbert/Aneth shales**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “The Aneth at its type section is composed of dark argillaceous dolomite with thin interbeds of black shale and dark-colored siltstone.” (Parker and Roberts, 1966, p. 2410)
- Restricted to northwestern Apache county
- Three to four ft thick at Walker Creek field.

### **Devonian Morenci/Portal/Percha shale**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “The upper 30-50 m is an olive-brown to reddish-brown shale called the Morenci shale...the shale is unfossiliferous, but regional stratigraphic relations suggest it correlates with the shale member of the Percha formation to the west and with the [predominantly fissile black] Percha Shale to the east in New Mexico.” (Schumacher, 1978, p. 178). “Member 2 consists of hard,

fissile, siliceous black shale that is readily differentiated from the members above and below by its dark color and complete lack of carbonate sediments.” (Sabins, 1957, p. 477).

- Possible present across most of Graham County and eastern Pima County in southeastern Arizona
- “Thickness of the shale member ranges from less than 10 ft to more than 200 ft.” (Schumacher and others, 1976, p. 64)

### **Cambrian Bright Angel shale**

- No geochemical analyses, unknown total organic carbon content (TOC)
- “The Bright Angel Shale is a mixture of many lithologic types, mostly mudstones, and fine-grained sandstones, but the dominant rock is a shaley, green mudstone. Some of this green rock is smooth, micaceous, and fissile; some is covered with fucoidal structures, and splits along irregular, bumpy surfaces.” (McKee, 1969, p. 80) “Lithologically the formation consists of sandstone, siltstone, and shale.” (Middleton, 1989, p. 275)
- Extends across the Arizona Strip north of Grand Canyon in northwestern Arizona
- “The thickness of the Bright Angel Shale decreases gradually from northwest [402 ft] to southeast [325 ft].” (Noble, 1922, p. 41-42). “The Bright Angle Shale is over 135 m thick in the western Grand Canyon, thinning markedly toward the east.” (Middleton, 1989, p. 275)

### **Precambrian Chuar Group Walcott shale member of Kwagunt Formation**

- Geochemical analyses with good TOC (up to 8.29%) published in AZGS OFR 98-17 and 02-01. “The TOC of 32 samples ranged from 0.07 (poor) to 8.29% (excellent) and averaged 1.93% (good).” (Wiley and others, 1998, p. 24).
- “The thin-bedded, black, highly organic shales, found primarily in thin beds of the Tanner and Carbon Canyon Members, in the upper portion of the Awatabi Member, and in most of the Walcott Member, indicate deposition in the dysaerobic to anaerobic water zones...” (Wiley and others, 2002, p. 49)
- Extends from north-central Arizona into south-central Utah and preserved in half graben
- Measured thickness of the Walcott Member ranges from 763 ft to 922 ft (Wiley and others, 2002, Table 1)

### **Precambrian Apache Group black facies of Dripping Springs Quartzite**

- Geochemical analysis with good TOC (up to 1.6%) published in RMAG 1984 (Table 1, p. 54)

- “It is not known if there was sufficient organic-rich material in the black facies of the Dripping Springs Quartzite and in the upper member of the Mescal Limestone to have generated and expelled significant volumes of hydrocarbons for migration and economic accumulation in reservoirs” (Desborough, Pool, Daws, and Scarborough, 1984, p. 52)
- Extends across most of Gila County in central Arizona
- Black facies of Dripping Springs ranges up to 120 ft thick

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