Silica-Sand Deposits in Arizona

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Introduction

Nearly pure quartz sands have become increasingly important for oil and gas production. Although used for hydraulic fracturing ("fracking") since at least the 1950s, the advent of directional drilling and improvements in hydraulic fracturing techniques have led to widespread exploitation of quartz sands that have appropriate properties for use in hydraulic fracturing ("frac sands"). Such sands are present in the upper Miocene to Pliocene upper Bidahochi Formation of northeastern Arizona. Other sand deposits are present in the State, but are not as well suited for use in hydraulic fracturing. This report is a brief review of the distribution and character of sands in Arizona that may have properties appropriate for use in hydraulic fracturing.

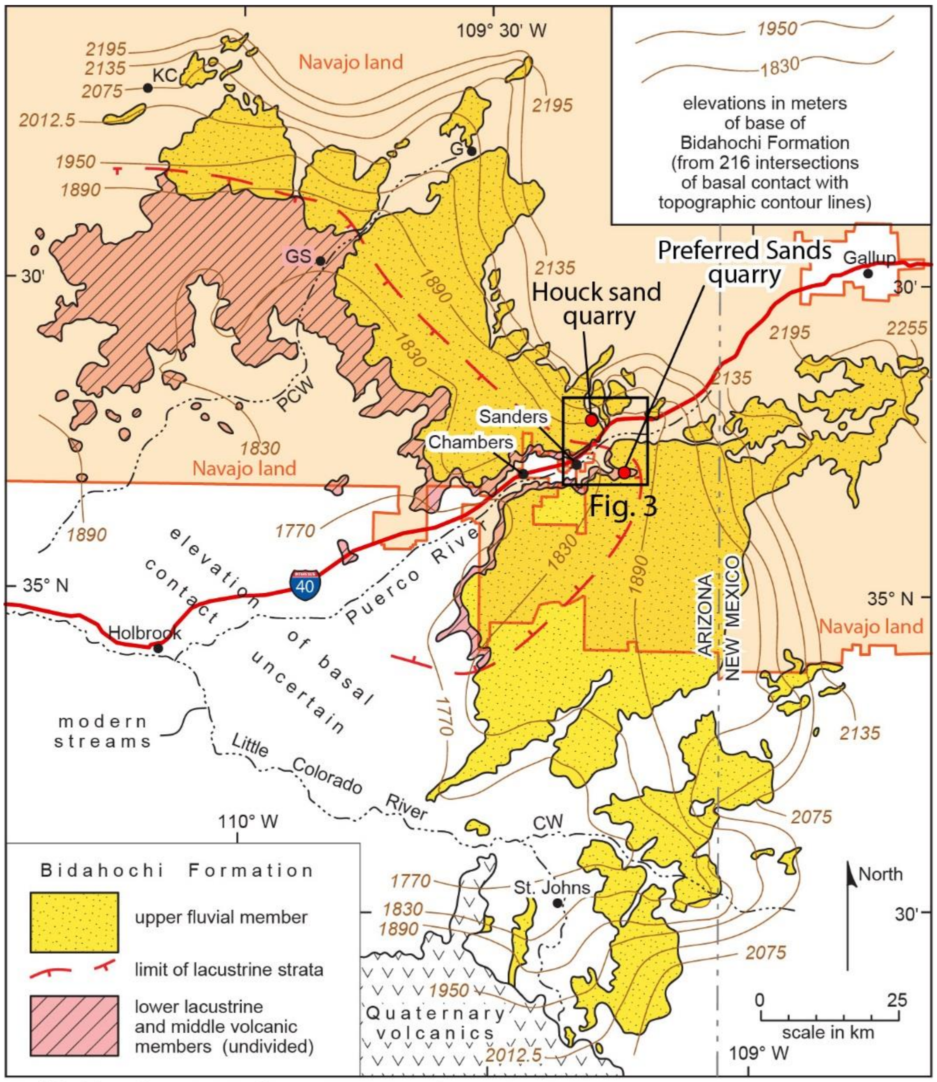
Bidahochi Formation

The Bidahochi Formation in northeastern Arizona (Figures 1, 2) consists of three members: (1) a lower playa and lacustrine facies of middle Miocene age (Dallegge et al., 2001, 2003), (2) a middle member consisting of mafic lava, volcaniclastic sandstone, and tuff of upper Miocene age (Sutton, 1974; Hackman and Olson, 1977; Ulrich et al., 1984; Damon and Spencer, 2001), and (3) an upper member that consists of fluvial and eolian sand, silt, and clay of uppermost Miocene to Pliocene age (Repenning and Irwin, 1954; Repenning et al., 1958; Love, 1989). Although the Bidahochi Formation has been subdivided into members, the members are facies with complex depositional relationships (e.g., Kiersch and Keller, 1955; Dickinson, 2013). The lower and middle members are completely missing from southern and eastern areas where the upper member rests on Paleozoic and Mesozoic strata (Figure 2).

In the Sanders area the upper, dominantly fluvial member includes bentonite clay deposits (it is not entirely clear that assignment of Bidahochi Formation members is meaningful in this area). The bentonite clay deposits, consisting of calcium montmorillonite and known as the Cheto mine deposits, have been exploited for desiccants, gellants, and acid-activated bentonites since 1924 (Kiersch and Keller, 1955; Eyde and Eyde, 1987). The overlying silts and sands of the upper Bidahochi Formation include sand deposits that contain 93-99% SiO_2 (Table 1), some of which contain a large fraction of sand in the -20 +40 mesh size that is generally preferred for frac sands (Tables 2-5). Furthermore, the deposits can be mined with a front-end loader, unlike other frac-sand deposits in Texas and elsewhere that must be mined and processed by blasting and crushing (Eyde and Eyde, 1987).

Figure 1. Geologic map of Arizona (from Richard et al., 2000) showing locations of sand-dune deposits in western Arizona and location of Figure 2.

The Preferred Sands plant and quarry (Figure 3) were active in 2015, with employment of 53 workers according to the U.S. Department of Labor (http://www.msha.gov/drs/drshome.htm). Employment reached 95 workers in 2012 (actually "sum of average employment" based on hours worked as reported to the USDOL). The quarry operations are located largely at the site of the former Cheto bentonite quarries. Arizona Silica Sand Company was engaged in sand production at Houck through 2011 according to the Arizona Mine Inspector's annual report. However, the Houck silica sand plant and quarry (Figure 3) appeared from aerial imagery to be inactive, and a search of the U.S. Department of Labor web site yielded no information using the search terms "Arizona Silica", "Houck Silica" and "Houck".



Modified from figure 2 *in* Dickinson, 2013, Geosphere, v. 9, p. 1–20

Figure 2. Distribution of the Bidahochi Formation in northeastern Arizona and adjacent New Mexico (modified from Dickinson, 2013). Also shown is a simplified outline of the extent of the Navajo Indian Reservation. In some areas mineral rights and surface rights are held by different parties.

Lower Colorado River Valley

Sand dunes are exposed over large areas in the Yuma Desert southeast of Yuma and at Cactus Plain southeast of Parker (Figure 1). In both areas sands deposited in the Colorado River Valley by the Colorado River have been displaced by winds and redeposited in sand dunes. Chemical analysis of dune sands from Cactus Plain near Parker and the Algodones Dunes in the Yuma desert near Yuma indicate silica content primarily in the 80-90% range, with none exceeding 90% (Zimbelman and Williams, 2002). Analyses of dune sands in the eastern Mojave Desert, west of the Colorado River, indicate silica content of consistently <80%, apparently because these sand deposits are upwind rather than downwind from quartz-rich sands delivered by the Colorado River (Zimbelman and Williams, 2002). Although Cactus Plain and the Algodones Dunes are both near railroad tracks and could be easily quarried, their physical properties are not appropriate for hydraulic fracturing sands because they contain too much feldspar and perhaps because of other factors such as small grain size.

Conclusion

The unusual purity of sand deposits in the upper Bidahochi Formation, containing little but quartz, and the adequate roundness and grain size, have made these deposits attractive for use in hydraulic fracturing. Other deposits in Arizona that could be economically quarried and processed have not been identified. Given the enormous aerial extent of the upper Bidahochi Formation, it seems likely that this area will continue to be exploited for frac sands as long as hydraulic fracturing remains a viable tool for oil and gas extraction.

Table 1. Geochemical analysis of sands (from unpublished AZGS file data)

	Arizona Silica Sand Co., 1992	Arizona Silica in Houck (probably Arizona Silica Sand Company) 1989 (12/20 mesh)	Arizona Silica in Houck (probably Arizona Silica Sand Company) 1989 (20/40 mesh)	Arizona Silica in Houck (probably Arizona Silica Sand Company) 1989 (-40 mesh)	Navajo sand deposit north of Chambers (1956)
SiO_2	93	98.6	98.5	96.0	97.91
Al_2O_3	1.4	0.5	0.56	2.74	0.94
Fe_2O_3	1.9	0.108	0.12	0.32	0.14
CaO	0.09	0.12	0.14	0.22	0.12
Na_2O	0.24				0.23
K_2O	0.7				0.09
MgO	0.08	<0.1%	<0.01	<0.01	0.08
TiO_2	0.02	0.030	0.030	0.026	
LOI (volitiles lost upon heating to 1000°C)*	0.2	0.61	0.61	0.64	0.94
Total	97.63	99.968	99.960	99.946	100.45

*LOI represents % acid-soluble material

Table 2. Sand sieve size (% retained) (from unpublished AZGS file data)

Sieve size	Arizona Silica Sand Company, 1993	Arizona Silica Sand Company, 1993 (plaster sand)
+30	0	1.2
-30 +40	19.8	6
-40 +50	46.7	24.2
-50 +60	13.6	12.3
-60 +70	9.5	14.1
-70 +100	9.4	25.7
pan	1	16.5
total	100	100

Table 3. Sand sieve size (% retained) (from unpublished AZGS file data)

Sieve size	Balcomb lease in Burntwater Wash (76% of sands -10 +60)
-10 +20	15.7
-20 +40	39.3
-40 +60	21.4

Table 4. Sand sieve size (% retained), sand deposit north of Chambers, location uncertain (from unpublished 1956 AZGS file data)

Sieve size	Area 1	Area 2	Area 3	Area 4	Area 5
+10	0.11	0.11	0.04	1.05	1.27
-10 +20	35.31	37.2	29.53	38.17	27.09
-20 +40	32	39.34	34.34	21.28	28.39
-40 +60	16.5	12.2	21.68	13.9	19.58
-60	16.08	11.15	14.41	25.6	23.67

Table 5. Sand sieve size (% retained)(from Kiersch, 1955)

Sieve size	Bidahochi Fm., 14 miles N of Chambers	Bidahochi Fm., 1/2 mile SW of Klagetoh (~20 miles N of Chambers)
-12 +16	34.1	0.1
-16 +20	61.1	16.7
-20 +32	2.8	40.1
-32 +40	0.4	30.5
-40 +60	0.3	6.7
-60	0.8	5.3
total	99.5	99.4

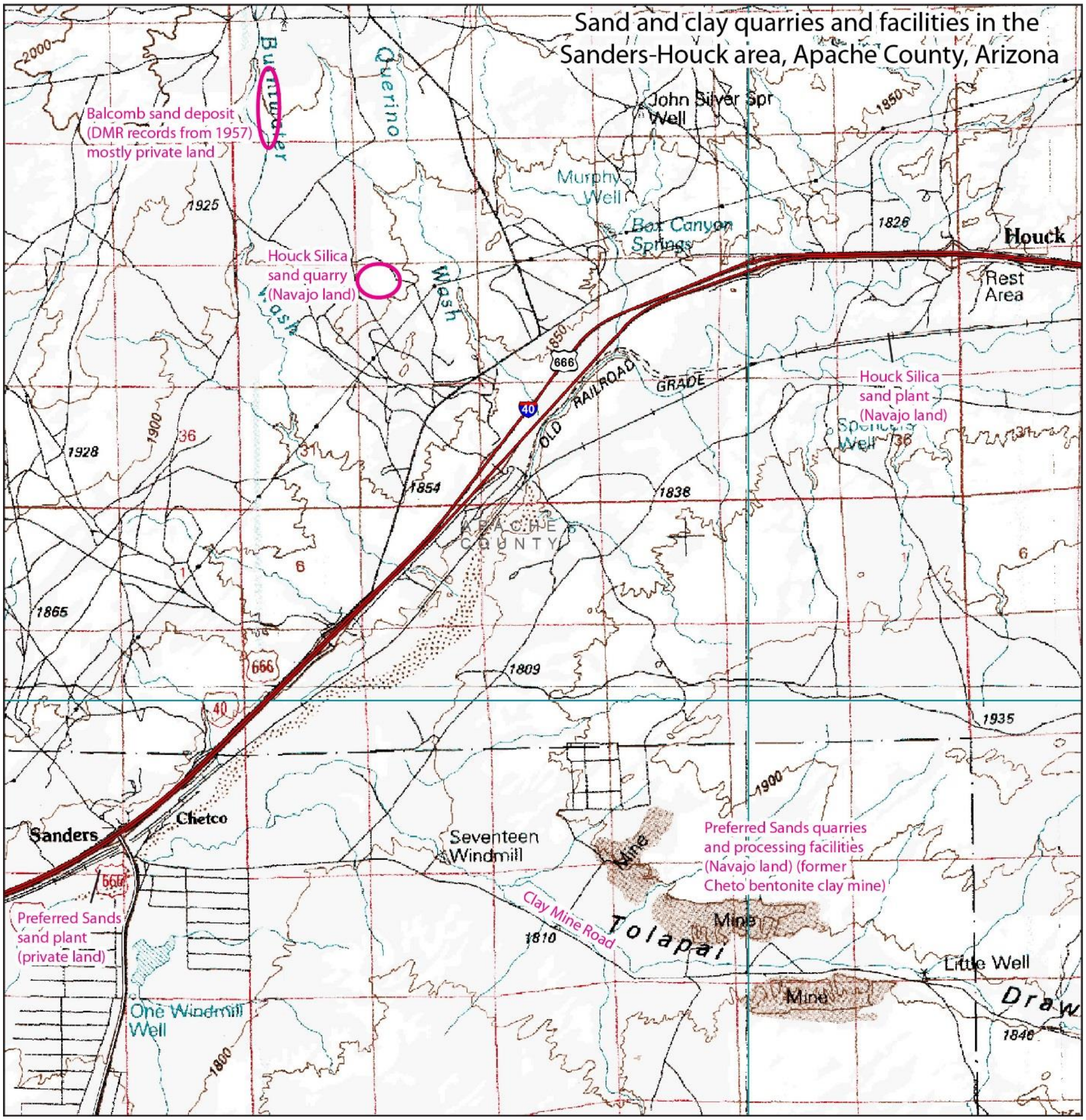


Figure 3. Location map for quarries and facilities associated with silica sand deposits in the Sanders – Houck area.

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