Geology, Mines, and Minerals of Tombstone

Numerous episodes of mountain building and sedimentation have left a record in the rocks of the Tombstone Hills. The oldest rocks there are the phyllites and metarhyolites of the Pinal Schist, which was dated at 1,695 Ma in the nearby Little Dragoon Mountains (Silver, 1967). It is intruded by granite, which may be similar to the granite dated at 1,420 Ma in the nearby Little Dragoon Mountains (Silver, 1978). The Precambrian rocks are unconformably overlain in the Tombstone Hills by a thick sequence of Paleozoic quartzite, limestone, and siltstone ranging in age from Cambrian (about 500 Ma) through Permian (about 250 Ma). These sedimentary rocks generally are excellent hosts to mineralization, as the limestones are reactive and the more resistant quartzites fracture easily under tectonic stress and provide pathways for veins and mineralization.

The Laramide orogeny (85-43 Ma) is represented in the Tombstone Hills by three structural and two igneous-mineralization types. The east-west faulting that uplifted Government Butte was emplaced early in the Laramide and may be related to early movement on the Prompter fault. The silver mineralization in the main district was emplaced in association with northeast structures and caldera volcanism and intrusive rocks (74 Ma). A later intrusion of quartz monzonite porphyry and rhyolite (63 Ma) in the northern and eastern Tombstone Hills is of the same age and style as porphyry copper mineralization elsewhere in southern Arizona (Wilt, 1993).

The principal past production from the Tombstone mining district has been silver (Ag) from high grade veins associated with the intersection of north-northeast-striking fissures and andesite dikes with the fractured crests of northwest-trending anticlines (Butler and others, 1938). Silver mineralization has been dated at 74.5 million years ago (Ma) and alteration at 72 Ma (Newell, 1974). It is probably related to the intrusion of the Schieffelin Granodiorite and associated tuff, the Uncle Sam Tuff, which have been dated at 76 Ma and 73.5 Ma (Creasey and Kistler, 1962; Marvin and others, 1973). A later period of mineralization could be associated with the Tombstone rhyolite, dated at 66.6 Ma (Marvin and Cole, 1978) or 63 Ma (Newell, 1974) and the associated Extension/Comstock quartz monzonite porphyry in the eastern part of the Tombstone district, dated at 62.8 ± 2.6 Ma (Drewes and others, 1985).

The first mining claim in the Tombstone district was located in 1857 (Butler and others, 1938), but mining did not commence until prospector Ed Schieffelin located rich Ag deposits at Tombstone in 1877. Development and mining in the Tombstone district then boomed (Tenney, 1929), with approximately 167 mine names in the district (MinDat.org, 2011). Oxide ores were mined from above the water table in the early years, but water plagued the district from the beginning. A lack of sufficient water in the early years meant the first mills at Tombstone were built along the San Pedro River, 9 miles to the west, which incurred high transportation costs. The situation reversed in March 1881 when water was encountered in the Sulphuret mine at a depth of 520 ft. Pumping was initiated in 1884 to dewater the mines and was successful for 3 years until fire destroyed the pumps. Coupled with low Ag prices at that time, many mines were forced to close. In 1900, the larger mines in the eastern part of the district were consolidated into the Tombstone Consolidated Mining Company. With new, larger pumps, mining operations below the water table resumed. In 1911, the pumps failed once more, the lower levels were allowed to flood, and mining by the Tombstone Consolidated Mining Company ceased. The smaller mines continued mining above the water table for several years, but by 1918 most of the mines were operated by lessees. By 1911, the rich deposits above the water table were depleted and Ag prices had declined to $0.50 per oz.

The price of Ag had the greatest effect on the success and failure of the Tombstone mines (Devere, 1978; 2010; Bailey, 2004). Most of the ore was produced during the 38-year period from 1877 to 1915, during which silver prices declined, financial panics ensued, and the United States currency was removed from the silver standard. In 1911, the silver price of $0.55 per ounce was less than half that in effect when Schieffelin discovered Tombstone. In 1914, the Phelps Dodge Corp. began mining under the name of Bunker Hill Mines Company, concentrating on the lower grade Mn-Ag ores at shallower depth above the

water table until 1933. With the repeal of the Pittman Act in 1923, the price of Ag plummeted and the mines closed (Table 1).

Between 1980 and 1985, Tombstone Exploration, Inc. operated an open pit mine on the Contention vein, and produced up to 3,000 tons per day of ore averaging approximately 1.25 ounces Ag and 0.02 ounces Au, recovered by cyanide leaching. Graves (1985) reported that 2 million ounces of Ag and 10,000 ounces of Au were produced in the period from 1970 to 1985, mostly from the TEI open pit operation, and in a small part by the Partnership mine dump consolidation (Greeley, 1984).

Stanton Keith (1973) concluded that through 1970 the total value of Tombstone production exceeded $38.8 million. Keith stated that through 1970, the Tombstone mining district produced not less than 1.5 million tons of Ag-bearing ore, either with Pb or Mn. He calculated that the yield between 1879 and 1970 was approximately 1.5 thousand tons of Cu, 22.5 thousand tons of Pb, 9,000 tons of Mn ore shipped during war years, 590 tons of Zn, 240 thousand ounces of Au, and 30 million ounces of Ag. He estimated that by 1890 over one-half the total Tombstone district Ag production had been extracted. A more recent production history was summarized by Stanley B. Keith (2002) (Table 2).

Museum quality specimens of minerals from Tombstone are rare, but the unusual telluride and chloride minerals are interesting. The Tombstone ores were mainly silver chloride varieties, with a little Pb and some telluride ore. Hypogene silver-bearing minerals included hessite, tetrahedrite, and galena (Rasor, 1937). Tellurates were described by Williams (1978). Alabandite was found to be the only definitely hypogene manganese mineral, although hollandite, psilomelane, and cryptomelane also occur. Bromargyrite, embolite, cerargyrite, argentite (acanthite), stromeyerite, native silver, native gold (Butler and others, 1938), and argentojarosite were identified as supergene ore minerals. The zone of oxidation was thought to be at least 600 ft deep (Rasor, 1937; 1939), and bromargyrite was believed to be the most abundant supergene silver mineral. High concentrations of manganese were associated with the Prompter fault, and the principal Mn production was derived from the Oregon, Prompter, Lucky Cuss, Luck Sure, Bunker Hill, and Comet mines (Wilson and Butler, 1930). Psilomelane, the major manganese mineral, typically occurred in pipes and chimneys in limestone horizons. Principal minerals are listed in Table 3.

Table 1 Production history, Tombstone mining district

Period	Price of Silver (USD)	Production	Remarks
1877–80	1.15 – 1.20	$2,318,567	Discovery and early development. Mills built on San Pedro River.
1881–86	0.99 – 1.14	16,877,175	Active development and large production. Water encountered in mines in 1882, and mills built at Tombstone.
1887–96	0.63 – 1.05	4,564,650	Decreased production due to depletion of many of the large ore bodies above water level.
1897–1911	0.52 – 0.68	5,575,900	Consolidation of principal properties and attempted de-watering of district by a 1,000-foot pump shaft.
1912–14	0.553 – 0.615	379,917	Lessee operations.
1915–17	0.507 – 0.824	1,117,687	War period. Considerable production of manganiferous silver ore and concentrates.
1918–32	0.282 – 1.12	5,150,789	Mainly lessee operations. Production of silver during 1918 –22 stimulated by Pittman Act.
1933–36	0.35 – 0.77	1,118,325	Production stimulated by increased price of gold and silver.

Source: Butler and others, 1938, p. 39; Note: USD = United States dollars

Table 2 Estimated mine production, Tombstone district

Mineral System/ Synonym (Mineral Zone)	Production Period (years)	Ore (short tons)	Au (oz)	Ag (oz)	Cu (lb)	Pb (lb)	Zn (lb)
Argenta	1922-1924	184	10	3,539	1,225	206	
Bunker Hill	1889-1931	382,330	32,404	4,407,706	2,963,902	7,461,919	45,192
Contention	1880-1885	98,252		5,240,721			
Contention/ Grand Central	1881-1950	306,090	7,815	5,377,798	286,771	6,345,686	
Galvez	1910-1924	295	81	4,382	2,149	1,796,733	
Good Enough	1884-1913	174,603	7,560	5,367,114	21,109	1,560,100	
Herschel	1905-1935	11,430	2,060	320,085	48,068	1,167,270	
Ingersol	1922-1932	1,359	378	39,273	11,689	227,393	
Lucksure	1905-1918	2,324		24,817	1,445		
Old Guard	1905-1935	2,644	383	59,516	61,574	186,887	
Rocky Bar	1920-1924	510	7	17,954	2,497	91	
Soltice	1914-1940	475	107	20,761	841	133,865	
State of Maine	1921-1950	30,343	9	104,696		2,667	
Sunset	1919-1927	419	3	11,443	5,644	10,458	
Tombstone Extension	1930-1954	26,680	1,308	222,106	90,930	14,304,882	
Tombstone Group	1903-1957	451,927	64,302	4,907,169	3,879,915	13,566,470	214,517
Toughnut-Empire	1879-1936	108,697	4,006	4,260,112	32,850	1,222,400	
Vizina	1880-1891	12,726		517,079			
Tombstone (combined)[1]		2,677,138	240,844	25,926,156	5,354,277	107,085,538	2,141,711
Tombstone (combined)[2]	1879-1981	2,953,296	131,468	32,076,966	7,763,447	49,854,350	555,527

Source: [1]Singer (1993); [2]Keith (2002)

Table 3 Principal minerals of the Tombstone mining district

Native elements	Sulfides	Haloids	Oxides	Carbonates	Sulfates
sulfur	galena	cerargyrite	quartz	calcite	barite
tellurium	argentite	bromargyrite	cuprite	rhodochrosite	anglesite
gold	chalcocite	embolite	tenorite	cerussite	jarosite
silver	sphalerite	fluorite	hematite		plumbojarosite
copper	alabandite		magnetite		
	covellite		hetaerolite		
	bornite		polianite & pyrolusite		
	chalcopyrite		manganite		
	pyrite		psilomelane		

Source: www.mindat.org (accessed 2011)

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Friday, April 13 – Dealers selling at the Clarion 5 to 10 PM

Saturday, April 14 – Symposium Program

8:00 - 8:45 -	**Coffee Hour**
8:45 - 8:50 -	**Welcoming Remarks and Introductions**
	Arizona Localities
8:50 – 9:30–	Minerals of Washington Camp and the Patagonia Mountains – Barbara Muntyan
9:30 – 10:10 -	Geology, Mines, and Minerals of the Tombstone Area– Jan Rasmussen
10:10 – 10:40 -	**Break**
10:40 – 11:20 -	Gemstones of Arizona – Wolfgang Mueller
	Arizona Mineral History
11:20 – 11:50 -	The Mineralogy of Arizona: Past, Present, and Future – Raymond Grant and Marcus Origlieri
11:50 – 1:10 -	**Lunch and silent auction**
1:10 – 1:50 –	History and Development of Mining in Arizona before Statehood (1912) – Jim McGlasson
1:50 – 2:30 -	Arizona - 100 years of Collecting - Les Presmyk
2:30 – 3:00 -	**Break**
3:00 – 3:40 –	Celebrating 40 years of Mineralogy at the Arizona - Sonora Desert Museum - Anna Domitrovic
3:40	Arizona Territory mineral treasures and "mysteries" in the Vaults of the Yale Peabody Museum – Stefan Nicolescu
4:30 - 5:30	Dealers selling in rooms
5:30 - 6:30	Social Hour

MINERALS OF ARIZONA

Twentieth Annual Symposium

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Saturday April 14, 2012

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