

Nature herself makes it clear that the production of gold is laborious, the guarding of it difficult, the zest for it very great, and its use balanced between pleasure and pain.

—Diodorus Siculus, 1st Century B.C.

Chapter VI. Production and uses of gold

Production and consumption

Gold mining in one form or another goes back into antiquity at least for more than 4000 years. During the earliest times one can imagine that the winning of gold was a haphazard activity, nuggets of the native metal being plucked from some auriferous stream, the oxidation zones of gold or sulphide deposits or from residuum near such deposits. Production was probably erratic and generally unorganized. By the time of the Pharaohs, however, organized gold mining in the Arabian and Egyptian shields appears to have been well established, and gold was seemingly relatively plentiful compared with silver for in the Code of Menes, the first pharaoh, who reigned in Egypt about 3500 B.C., it was decreed that “one part of gold is equal to two and one-half parts of silver in value.” Since that time up to the fall of the Roman Empire gold appears to have been mined almost continuously mainly from placers but also from the oxidized zones of deposits in all organized societies throughout the world. There is evidence of ancient gold workings and placers ranging from Japan, through China, India, U.S.S.R., Turkey, the Mediterranean islands and lands, central Europe, Spain, France, Britain, Mexico, Central America and South America. The early Minoan goldsmiths had a source of gold for they produced some of the finest pieces of early gold work known to man (Frontispiece). The Greeks mined gold extensively throughout their empire and appear to have prospected for it far and wide judging from the legend of Jason and the Golden Fleece. The Romans, likewise, sought gold throughout their empire obtaining it from placers and mines in Spain, France, Britain, Germany, Central Europe and the Middle East. The yearly production of gold in the Roman Empire at the beginning of our Era can only be roughly estimated; a reasonable figure seems to be about 250 000 oz. One of the great gold placer areas in the Middle East was the river Pactolus in Lydia (a tributary of the present Gediz in Anatolia in Turkey). Another was the Pontic field in Turkey, on the southern shore of the Black Sea, possibly the site of the Garden of Eden and probably one of the sites of the Golden Fleece sought by Jason.

Nearly all of the gold mined by the ancients was wrought into idols, shrines, bowls, vases, flasks, cups and jewellery. Later, about 1000 B.C., gold and silver came into general usage for coins as a medium of exchange, certainly in all countries between the Indus and the Nile and probably on a much more widespread geographical basis. By Philip of Macedon's time (356 B.C.) gold and silver were generally valued in the ratio of 10:1. This value ratio did not change much through the centuries that followed for we find that in England the ratio in 1464 was 11:1 according to the recorded mint price. Since then there has been considerable fluctuation in the value ratio as shown in Table 81. There is an interesting

comment in the *Engineering and Mining Journal* (vol. 95, p. 1163, 1913) with regard to the origin of the ratio of value between gold and silver that merits quotation:

“I have endeavored to discover as to how and when the ratio of value between gold and silver commenced, and as to what was its origin”, said Bedford McNeill, in his presidential address before the Institution of Mining and Metallurgy. “Sir David Barbour has called my attention to an interesting theory of Professor D’Arcy Thompson, ‘that the origin of the ratio may have been astronomical, gold being associated with the sun, and silver with the moon; the period of the earth’s revolution round the sun being 365¼ days, and that of the moon round the earth 27.32 days, it will be found that the ratio between these figures is very nearly 13⅓, and this figure 13⅓ was the ratio that was fixed between gold and silver during the Babylonian Empire (2000 B.C.) down to the Lydian Empire (500 B.C.).’ Professor D’Arcy Thompson has also pointed out that the Lydians made coins of what was called ‘electrum’, and reckoned one electrum coin as being of the same value as 10 silver coins of the same weight. It was supposed that the Lydians were unable to separate the gold from the silver, but when we find by assay that the proportions in these old coins of gold to silver were approximately as 73 and 27, calculating gold as 13⅓ times as valuable as silver, and we find that an electrum coin would be worth exactly 10 silver coins of the same weight, we cannot help but admit that the Lydian assayers must have been well versed in the science and practice of their art, and that such figures cannot be mere coincidences.”

Since the earliest times gold has been hoarded by kings, states, popes and individuals, the prime example being Croesus of the Mermnadae, last King of Lydia (560–546 B.C.). It is said that most of his fortune in gold came from the placers of the Pactolus, but it seems more likely that his wealth had a more widespread origin since the Lydians were renowned for their trading pursuits. How much gold was hoarded in ancient times is unknown, but the practice seems to have increased at the beginning of our era, so much so that during most of the Dark and Middle Ages both of the precious metals were scarce. Some of the scarcity was undoubtedly due to the exhaustion of most of the placers in Europe and the Middle East and also to a general decline in mining, the economic limits, in terms of depth, of profitable ore having been reached in many districts mainly because of engineering problems (ventilation and flooding by groundwater). It is estimated that the total annual production of gold during the Dark and Middle Ages probably averaged only about 100 000 oz.

Geographical exploration brought an abrupt change in this situation, the manifestations of which affect us to this day. With the rediscovery of America by the Spaniards in 1492 came the discovery of great stores of both gold and silver first in the islands of the West Indies, then in Mexico and finally in Central and South America. At first, great quantities of gold were looted from the natives, but as this source declined active placering and mining by slave labour provided

Table 81. Value ratio of gold to silver through the ages*

Year	Value ratio	Remarks, authority, etc.†
Prior to 3500 B.C.	1 or less	No records
c. 3500	2.5	In Egypt. Code of Menes
708	13.5	In Assyria. Cuneiform inscriptions at Nineveh
500	13.0	In Persia. Herod III
400	12.0	In Greece. Plato
404–336	12.0	In Greece, Peloponnesian war to time of Alexander
300	10.0	In Greece. Fall in gold value due to influx of Alexander's spoil
207	13.7	In Rome
186	10.0	In Rome
58–49	8.9	In Rome. Fall in gold value due to influx of Caesar's spoil
1–37 A.D.	10.9	In Rome. Reigns of Augustus and Tiberius
54–68	11.8	In Rome. Reign of Nero
81–96	11.3	In Rome. Reign of Domitian
312	14.4	In Byzantium. Reign of Constantine
438	14.4	In Rome and Byzantium. Theodosian code
864	12.0	In Europe. Edictum Pistense
1344–1482	11.1	In England. Mint returns
1482–1492	12.2	In Europe
1492	11.0	In Europe. Discovery of America
1497	10.7	In Spain
1550	12.0	In Europe
1641	14.0	In Europe. Moran and John Locke on money
1690	16.0	In Europe. Sir Isaac Newton
1730	16.0	In Europe. Kelly's "Cambist"
1760	14.3	In London. Del Mar
1800	15.7	In Europe & U.S.A. EMJ
1850	15.7	In Europe & U.S.A. EMJ
1886	22.0	In Europe & U.S.A. Discovery of the Rand
1890	22.1	In Europe & U.S.A. EMJ
1900	34.4	In Europe & U.S.A. EMJ
1910	38.2	In Europe & U.S.A. EMJ
1915	38.2	In Europe & U.S.A. 1st Great War, EMJ
1920	20.8	In Europe & U.S.A. EMJ
1930	60.8	In Europe & U.S.A. EMJ
1935	45.5	In Europe & U.S.A. EMJ
1940	50.0	In Europe & U.S.A. 2nd Great War, EMJ
1950	41.2	In Europe & U.S.A. EMJ
1960	38.5	In Europe & U.S.A. EMJ
1970	21.1	In Europe & U.S.A. EMJ
1975 (January)	41.9	In Europe & U.S.A. EMJ

* The figures given are calculated value ratios in the currency of the time and all should be read as follows: 2.5 indicates that at the stated time gold was two and one-half times the value of silver; 12 that it was twelve times, and so on.

† Sources of information include various documents in the British Museum and British Library, London; National Museum, Athens, Greece; Vatican Library, Rome; Jacob (1831), and Del Mar (1880). The values since 1800 were obtained mainly from the Engineering and Mining Journal (EMJ) annual volumes. No attempt was made to authenticate all of the values shown, and no adjustments have been made to compensate for differences between the various currencies of different countries. For a thorough discussion of the value ratios prior to 1880 see Del Mar (1880).

a large and continuous influx of gold and silver to Spain. Despite an attempt by the Spanish government to keep the precious metals to itself, they soon filtered over the whole of Europe, increasing the supply of money and inflating prices. It is estimated that from 1492 to 1600 more than 10 million oz of gold came from the Spanish Americas, which was about 40 per cent of the world production at that time. Marked increases in gold production from South America, particularly from the placers of Colombia, were registered during the period 1600–1800; for example some 48 million oz were won during the 18th century, accounting for about 80 per cent of the world production. Two further increases in the world gold production followed during the periods 1820–1880 and 1890–1920. The first marked the discoveries of the great placer and lode mining areas of Siberia, California, Australia and New Zealand; the second followed the discoveries of placers and bedrock deposits in Alaska, Yukon, central Canada and on the Witwatersrand of South Africa. Since 1920 there has been only one period, 1933–1939, when the production of gold increased significantly. During and since World War II a general decline in the production of gold in nearly all countries except South Africa and the Soviet Union has taken place. In South Africa the average annual production for the last 5 years has been about 27.5 million oz; in the Soviet Union the annual production for the last 5 years has probably averaged 10 million oz, although this figure is only a rough estimate, the true value being a closely guarded state secret.

It is estimated that the total amount of gold won by man from the earth to 1975 is about 3 billion (3×10^9) oz. Of this amount some 2 per cent was produced prior to 1492; 8 per cent during the period 1492–1800; 25 per cent during the interval 1801–1900; and 65 per cent from 1901–1975, all figures being rough estimates.

Approximately 88 per cent of the annual world production of gold is obtained from primary deposits and placers (fossil and modern) mined essentially for gold. The remaining 12 per cent comes as a byproduct of base metal and silver mining. The average annual world production during the period 1971–1975 inclusive was about 49 million oz. The principal producing countries are shown in Table 82.

Table 82. World gold production

Country	Average annual production for years 1971–1975 inclusive (oz x 10 ⁶)
South Africa	27.5
U.S.S.R.	10.5
Canada	1.9
United States	1.5
Australia	0.8
Ghana	0.7
Others	6.0
Total	48.9

Sources: U.S. Department of the Interior, Minerals Yearbook (1971–1975); Mining Annual Review (1971–1975); Canadian Mining Journal, Annual Mineral Industry Review (February issue) (1971–1975); Department of Energy, Mines and Resources, Canadian Minerals Yearbook (1971–1975). The figure given for the U.S.S.R. is estimated.

Uses

The historical uses of gold are of interest: From the dawn of civilization until about 1000 B.C. the uses were restricted mainly to ornamentation, decoration and the display of princely power. This has often been called the decorative or ornamentative stage in the history of the precious metal. After 1000 B.C. gold came into general use as money and freely circulated until about 1916. This was the monetary stage in the history of the metal, although considerable amounts continued to be used for ornamental purposes. After World War I the movement of gold and its use as money was greatly curtailed and eventually restricted in many countries, most of the metal, except that permitted for the manufacture of jewellery, going straight from the mints into the vaults of most countries. This period continues to the present day, although there has been a relaxation in a number of countries that permit their citizens to own and trade in the metal. Since 1950 there has been increased industrial use of gold – sufficient it would seem to suggest that we are entering the industrial age in the history of the metal.

Specifically, the uses of gold depend essentially on its traditional role as a monetary measure by governments and central banks in the settlement of international balances; on its intrinsic quality as the most beautiful of metals; and on its chemical inertness, great malleability and high electrical and thermal conductivity. In its international monetary role gold is utilized mainly in the form of high purity bars, tablets or more rarely as coins with a specified gold content. In its other roles the metal is employed in the pure form or alloyed with other metals such as silver, copper and the platinum metals.

It is difficult to state accurately the apportionment of the annual world production of gold among its various uses. There are several reasons for this, chief of which is the tendency for certain financial institutions and individuals to add to their hoards of the metal. Rarely is the magnitude of these hoards made public nor are their annual increase or decrease known. The purchase of gold, for uses other than the manufacture of jewellery, industrial purposes, etc., is prohibited by law in many countries, but despite this hoarding is traditional in many Asiatic and European countries and is probably also common in North and South America. It is estimated that about 20 per cent of the annual world production of gold goes into the vaults of governments and central banks as a monetary reserve; some 5 per cent probably passes into the hands of private and corporate hoarders; and the remainder about 75 per cent, some 36 million oz, is used in fabricated articles. Of the last some 60 per cent is consumed in dentistry and the jewellery and coin industry; the remainder is utilized in a great variety of electronics and other industries.

Gold is the royal and aristocratic ornamental metal par excellence with a seductive natural colour, lustre and satinlike texture. Since ancient times this most beautiful of metals has traditionally enjoyed a use in articles of personal adornment, particularly in rings and a variety of costume jewellery. Considerable amounts of gold are also used in fountain pens, medallions, gold watches and in gold fillings in dentistry. Some gold has also been utilized since antiquity in the fabrication of chalices, cups, vases, shrines and a great variety of other articles cherished for their intrinsic value. In all of

these uses gold is generally alloyed with copper or silver, the fineness of the gold alloy being expressed in 'carats'. Pure gold is '24 carat gold'.

Pure gold or that containing a low percentage of silver or copper can be hammered into extremely thin foil, about 0.000005 in. in thickness. In the foil or leaf form gold has been used for a great variety of decorative purposes on buildings, statues and other articles since pre-Biblical times. Thin layers of gold welded to base metals such as nickel, copper or brass can be rolled or drawn into complex forms without rupturing the thin gold layers. Material of this nature is called gold-filled plate and is used extensively in various types of jewellery, watch cases, spectacle rims, etc.

The industrial uses of gold depend essentially on its softness, the ease with which it alloys with silver, copper or platinum metals, its great ductility and malleability, its great electrical and thermal conductivity and its chemical inertness and hence corrosion-resistance to oxygen, sulphur, most chemical compounds and nearly all of the single common acids. Most of the gold used in industry is consumed by the electronic and electrical engineering industries, the products ranging widely from coatings of vacuum tubes, specialized electrical contacts, electrical precision drawn wire leads, gold electroplate high frequency conductors, to printed circuits in computers, radios and television sets. Considerable amounts of gold are also used by industry in the fabrication of high temperature brazing alloys, linings for specialized chemical and nuclear plants, platinum-gold alloy spinnerets for viscose rayon plants, infrared and thermal reflectors in aircraft and space vehicles and heat shields for jet and rocket engines. Gold-coated window glass for buildings in hot climates and electrically heated windscreens having a thin transparent and conductive layer of gold are finding an increasing use in cars, aeroplanes, ships and locomotives throughout the world. Some gold is also consumed by the printing and furniture industries in the form of gold paints and by the ceramic industry in the form of organic 'liquid golds' for application in pottery and glassware. On firing or other treatment the organic gold compounds are reduced leaving a thin film of gold tightly bonded to the ceramic ware or glass. Small amounts of gold are also used for colouring glass, and gold salts are used to a small extent in certain photographic and medical preparations.

It seems probable that the industrial use of gold will increase substantially in the future as will also its use in jewellery and other articles of adornment. The amount of the annual increase is, however, conjectural, perhaps some 2 per cent of the present yearly production or about 1 million oz. One can also predict that there will be a substantial yearly increase in hoarding although the amounts cannot be reliably estimated. Presumably it will vary with the confidence that individuals place in their respective country's paper notes and base metal coinage. The fate of gold as a monetary standard in the settlement of international balances can only be conjectured. Should Utopia descend upon us we will have no need of an objective, tangible, enduring, weighable, readily transportable medium such as gold in our international financial transactions. But since that day appears far removed it would seem that gold will be that medium which will continue to keep all men honest in their trading and financial

manipulations despite views to the contrary by many of our modern economists, stimulated it would seem by the thoughts of John Maynard Keynes, who referred to the position of the metal in the modern world as that "barbarous relic". Gold is the discipline that curbs the power of the printing press. Stephen Leacock (1932) touched upon this point in a memorable address on gold:

We have to have – I would say 'stable prices'; you cannot have a world with all the prices stable; you can only have a world in which the price level moves slowly with a regular and intermittent oscillation. But you can have and must have a fixed exchange. You cannot have a foreign trade based on monetary speculation; you have got to have something absolutely stable for your dealings with foreign nations, and I tell you, gentlemen, I am convinced that there is nothing that will take the place of some absolutely metallic standard, some standard of things, and not of opinions.

The price of a troy ounce of gold at the time of writing (December, 1977) on the free market was approximately \$US 170; the equivalent price of silver was \$US 5.00 giving an Au:Ag value ratio of 34, a considerable increase since the time of Pharaoh Menes.

Those who wish to pursue the details of the production, uses and economics of gold should consult the informative works by Malcolmson (1907), Keynes (1930), Altman (1960), Badone and Spence (1961), Morgan (1965), Kavanagh (1968, 1976), Green (1970), Weil and Davidson (1970), West (1975),

Hogan (1975), Collins (1975), Fahlgren (1975), Vilar (1975), Fells (1975) and Fells and Glynn (1976).

As we look in retrospect at the last 5000 years of the history of gold we see that the noblest and most beautiful of metals has played a remarkable and sometimes dominant role in human experience and progress, first in an ornamental way, next in coinage, then as an international medium of exchange, and now as an indispensable element in industry. We see also that gold has elicited both good and evil works in man, as have also most other materials of this earth. On the good side of the coin, avarice for the metal has given us great discoveries both chemical and geographical; on the evil side the *auri sacra fames* has led to conquest, enslavement of nations, civil contention and the vilest treatment of men ever devised.

As we look in prospect we perceive an industrial vista where gold will play an ever increasing role in the production of high speed computers, telecommunications, space vehicles, pharmaceuticals and a thousand other artifacts of future civilizations. We perceive also that man will lose none of his fascination for the metal that he has long admired for its natural beauty and enduring qualities.

Long have I laboured in the realms of gold
And much have I learned.

