*Indian Journal of History of Science,* 44.1 (2009) 95-102

# HISTORICAL NOTES

## On the Sanskrit Word, *Svarṇaja* Used for Metal, Tin*

The metal, tin, was coined from the word *svarṇaja* since it was recovered from *svarṇa* (gold), in which it was present as an impurity. The present paper discusses scientifically the genesis of the presence of tin in primary gold. In several locations in the world, both gold and cassiterite – the principal ore of tin, occurred together in alluvial placer deposits. In order to avoid excessive losses of gold in the tailing, a gold concentrate containing a large proportion of cassiterite was obtained from such a deposit by panning process. When such a concentrate was melted in a reducing atmosphere, cassiterite is reduced to tin and a gold-tin alloy is obtained. The word *svarṇaja* hints that effort was made to preserve properties of tin from gold and attempt has been made to identify possible source of such a gold-tin alloy in ancient and medieval India.

The most common word used for metal tin in ancient Sankrit texts was *vaṅga*. Another popular word for it was *raṅga*. However, there were several uncommon Sanskrit words for tin. One such word was "*svaraṇaja*". Both Apte and Monier-William have quoted this word in their respective lexicons. They have given tin as its meaning. The famous Sanskrit lexicon *Amarakosa* of Amarasimha (belonging to approximately 225 AD) has not mentioned the word *svaraṇaja* for tin. The *Śabda-Kalpadrum* compiled by Rājā Rādhākānt Dev (c. 1819-58 AD) has also quoted this word for tin. Moreover, it has referred to the original reference from the lexicon *Abhidhāna Cintāmaṇī* (iv.108) compiled by Hemachandra, which has stated *svaraṇaja* together with other toponyms for tin, as follows:

*vaṅgaṃ trapuḥ svarṇajanāgajīvane mṛdvaṅgaraṅge gurepatrapiccaṭe |*

*syāccakrasaṃjñaṃ tamarañca nāgajaṃ kastīramālīnakasiṃhale api ||*

*Eng.tr: 'Vaṅga, trapu, svarṇaja, nāgajīvana, mṛdvaṅga raṅga, gurupatra, piccaṭa, cakra* and its synonyms, *tamara, nāgaja, kastīra, ālīnaka* and *siṃhala* are the words used for tin'.

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It appears that the earliest reference to the word *svaraṇaja* is in the lexicon by Hemachandra, the time period of Hemachandra being c 1088-1175 AD as approximated by Upadhyaya (1983).

The *Śabda-Kalpadrum* has given the literal meaning of *svarṇaja* as '*svarṇat jāyate iti*' which means that the *svarṇaja* is that which has been obtained from *svarṇa*, i.e. gold. It appears that tin was present in some types of gold, and people were separating tin from gold. It is because of this fact that tin was also recognized as some thing which is recovered from gold, and hence the name *svarṇaja*.

As in modern times, gold was recognised as of two types in ancient times also, viz., primary gold and recycled gold. Primary gold was that gold which was obtained from the vein or placer deposits. Recycled gold was obtained from the refining of the recycled gold such as old jewellery. It appears most unlikely that tin was recovered from recycled gold, as tin is not known as a common alloying element. However, the adulteration of gold with tin can not be ruled out. Tin might had been recovered from such adulterated gold. It is most likely that tin was recovered from primary gold.

A pertinent question which may be asked is whether tin could be present in primary gold. If so, what is the scientific explanation for such an occurrence. Since tin was separated from such gold, tin was named as *svarṇaja*. A light on these querries would justify the coining of the word *svarṇaja* for tin. An attempt has been made in the present paper to discuss these aspects scientifically.

In ancient times, the most important source of gold was alluvial placer deposit. This type of deposit was also common in the medieval times. Alluvial placer gold is derived from the weathered out rocks containing vein gold deposits. Gold is highly resistant to weathering. The gold particles along with weathered rocks are washed down the mountains, and are subsequently deposited in the sand and gravel of rivers. Higher density gold particles were separated from lower density sand gravel of the river by panning process.

The principal ore of tin in ancient and medieval times was cassiterite. It is also very resistant to weathering, and is obtained as alluvial placer deposit. Similar to gold, higher density cassiterite particles were also separated from lower density sand and gravel by panning process. This type of casseterite deposit was an important source of tin in ancient and medieval times.

Thus, it is apparent that the mining method and the mineral beneficiation technique used for gold and cassiterite, have some similarities as both were obtained as alluvial placer deposits.

During the flow of a water stream containing mineral grains of different specific gravity and size flows, the simultaneous deposition of different mineral grains can occur depending on fulfilling certain conditions. Rubey (1933) has introduced the concept of "hydraulic equivalence" for understanding the behaviour of simultaneous deposition of grains of heavier and lighter minerals. He stated that the grains of same settling velocity are deposited together. He assumed the spherical shape of grains. The settling velocity of grains is a function of grain size and the specific gravity of grains. Thus, smaller size grains of heavier minerals deposit together with larger size grains of lighter minerals. A concept of "hydraulic equivalence size" has been introduced in the literature. Reid and Frostick (1985) have mentioned the quartz settling equivalents of cassiterite and gold. A spherical cassiterite (specific gravity 7) grain has a diameter, which is only 0.52 of its quartz equivalent, while gold (specific gravity 19), due to its even higher specific gravity contrast, has a diameter only 0.32 of quartz grain.

If the water stream contains gold, cassiterite and quartz particles, all the three types of particles would deposit together but have different mean sizes. The mean size of the deposited particles would decrease in the sequence-quartz, cassiterite and gold. Thus the size of gold flakes deposited with fine size cassiterite particle would be very fine, and their separation during panning of auriferous cassiterite would be rather difficult. Such an auriferous alluvial placer deposit can be concentrated into gold-rich concentrate by panning. The complete separation of gold particles from cassiterite or quartz would lead to a greater loss of gold in the tailing. In general, the common practice was to pan gold concentrate along with higher amounts of residual mineral impurities from the auriferous sand to decrease the gold loss in the tailings. When such a gold concentrate containing residual cassiterite and quartz impurities is melted in a crucible under oxidizing atmosphere, almost pure liquid gold would be obtained, and the residual oxide impurities such as a cassiterite and silica would be removed as a slag. Alternatively, if such a gold concentrate is melted under reducing atmosphere, cassiterite will be reduced to tin depending on the ratio of the partial pressures of carbon monoxide and carbon dioxide in the atmosphere. Thus, tin will enter into liquid primary gold.

There are several references covering a wide range of time period from ancient to pre-modern, which suggest that gold and cassiterite can be present simultaneously in alluvial placer deposits. Dube (2006a) has discussed these references in detail. Some of the important references where such a deposit was found are as follows: Alutiae (as told by Pliny), Taurus (near Nigde, Turkey), Malaysia, Thailand, Myanmar, Cornwall, New Zealand, and Alaska.

Pliny (1999) was perhaps the first writer who pointed out the presence of cassiterite along with gold deposit. He writes:

> "…….The Greeks applied to it the name cassiteros…..It (Cassiteros) is also found in the gold mines called "Alutiae" through which a stream of water is passed that washes out black pebbles of tin mottled with small white spots, and of the same weight as gold in the bowls in which it is collected, and afterwards are deposited in the furnace, and fused and melted in to white lead (tin)".

The contact between India and various countries of Southeast Asia dates back to pre-historic times. Southeast Asia was described in Sanskrit literature by generic terms-*Suvarṇabhūmi* (The Land of Gold) and *Suvarṇadvīpa* (The Island of Gold). The contact between India and Southeast Asia became vigorous at the time of the beginning of the Christian era, and strengthened continuously in the subsequent centuries. There was an intense commercial and trade activities between India and Southeast Asia in the medieval period. Gold was one of the important product, which was brought to India from Southeast Asia through trade and commerce. In fact, Southeast Asia was an Indian "El-Dorado" (Dube 2006b). It is against this background that the occurrence of auriferous cassiterite in Southeast Asia is of significance in the present context, and would be discussed in detail.

Malaysia was an important tin and gold producing country in ancient times. Both cassiterite and gold were largely mined as alluvial placer deposit. Penisular Malaysia consists of three main geological domains, which are parallel to peninsula. Scrivenor (1928) designated them as Western tin belt, Central gold belt, and Eastern tin belt, as shown in Fig. 1. There is evidence that gold also occurred in the certain parts of the tin-rich Western belt. In recent times, economic gold deposits have been found in the east coast of Malay Peninsula. On the basis of the style of mineralization, Yeap (1993) proposed to divide the gold mineralization in Peninsular Malaysia into four belts or zones which are parallel, some juxtaposed and some overlapping with the Eastern and Western tin belts or zones, as shown in Fig. 1. It is not unlikely that tin ore and gold deposited together in alluvial placer

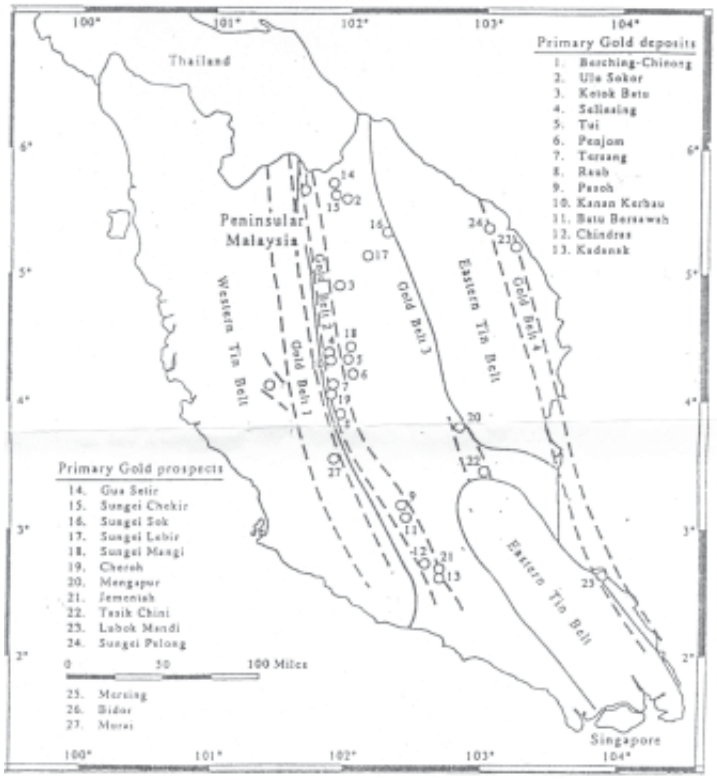


**Fig. 1.** Peninsular Malaysia showing tin mineral belts and primary gold occurrences

deposit because of the proximity of tin and gold belts. In this context, the statement of Emmons (1937), who was Professor and Head of Geology and Mineralogy at the University of Minnesota, USA in the early part of the twentieth century, is of importance:

> *"In west Malaya, however, the gravels of some of the tin placers carry considerable gold."*

Gerini (1909) has discussed the old gold working sites in Malay Penisula. Many of the gold mines developed by European enterprises in the Malay Peninsula in the nineteenth century were originally worked at a very early age. The evidence of gold working were innumerable in the area, and were termed "wonderful" by the Europeans, who first noticed them. Gerini (1909) has opined that the Hindus (Indians) visiting migrating to the Malay Peninsula planned, directed and superintended the gold mining activities at most of these sites in the ancient times.

Gerini (1909) also noticed old workings of tin mines in various parts of the Malay Peninsula.

Al-Mās'ūdi (943 AD) has mentioned the existence of tin, silver, gold and lead mines around the countires of Kalah and Panhang (Pahang) in the Malay Peninsula (Al-Mās'ūdi 1861):

> "…..Mines of tin *(al-rasas)* and mountains of silver. There are also mine of gold and lead *(al-rasas al-abyad)*".

Lajonuiere (1909) stated that a large number of Hindu colonies were situated in widely remote areas of Malay Peninsula in ancient times, such as Chumphon, Caiya, the valley of river bandon, Nakhon Sri Dhammarat (Ligor), yale (near Patni) and Selensing (in Pahang) on the eastern cost, and Malacca, Province Wellesley, Takua Pa, and the common delta of river Lanya and Tenasserim on the western coast. Further, Lajonquiere (1909) also sated that the group of people occupying the colonies at Selensing, Panga, Puket and Takua Pa prospered by the exploitation of tin and gold mines. It is not unlikely that gold-rich concentrate obtained from the alluvial placer deposits of this areas contained cassiterite as impurities.

Suthakorn (1922) has discussed in detail the important types of tin deposits found in Thailand. The primary Pilok tin deposits in Thong Pha Phum district in Thailand contains cassiterite along with locally gold. Similarly, small amount of gold is locally found in tin-bearing quartz veins in Ratchaburi, Suanphung district. Small amounts of gold have been reported to be present in the cassiterite bearing veins in Prachuap Khiri Khan Area. Suthakorn has reported that alluvial placer tin ore deposit in many localities in Thailand is associated with gold flakes. Such a type of auriferous tin ore deposit is found in Pilok area, Kāñcanaburi province, Bang Saphan ara, Prachaua Khiri Khan Province and Tomo area, Narathiwat province, etc. It is interesting to note that the word "*Kāñcana*" in Kāñcanaburi means gold in Sanskrit language, which had a great influence in South East Asia in ancient and medieval times.

From the above discussion, it is apparent that gold containing tin can be produced from naturally occurring gold-rich concentrate containing cassiterite as an impurity. The amount of tin present in the primary gold depended on the amount of cassiterite present in the gold-rich concentrate produced by panning of alluvial placer deposit. A higher amount of cassiterite in the resulting gold-rich concentrate obtained by panning, was preferred because of lesser losses of gold

associated with such a practice. The production of gold containing higher amounts of tin was a real possibility. The presence of tin in gold was detrimental to its physical and mechanical properties, and hence there was a need to remove tin from gold. It is against this background that Indians were removing tin from gold, and coined another toponym for tin as *"suvarṇaja"*. It would be interesting to explore as to how tin was removed from gold in ancient times. It is quite possible that such a gold containing considerable amounts of tin was brought to India from Southeast Asia, keeping in view the fact that there was a vigorous contact between India and Southeast Asia, and there was a tradition of the availability of gold and cassiterite in the alluvial placer deposit of some parts of Southeast Asia.

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