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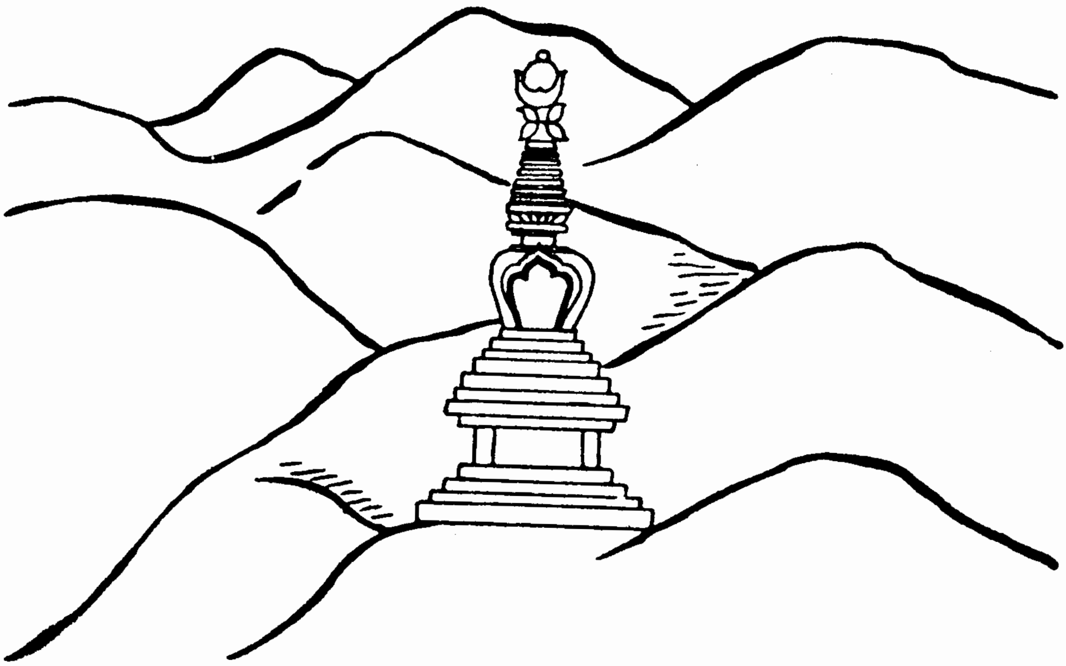

NEW SERIES

1991 No. 1-3

29 October 1991
SIKKIM RESEARCH INSTITUTE OF TIBETOLOGY
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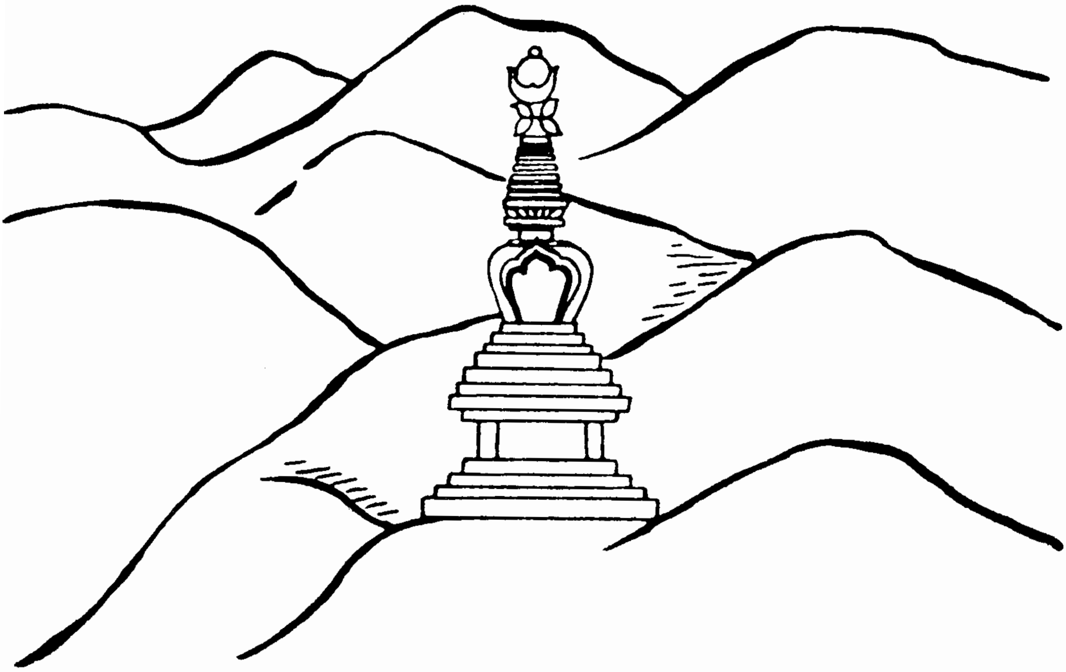

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STATUARY METALS IN TIBET AND THE HIMĀLAYAS: HISTORY, TRADITION AND MODERN USE

E Lo Bue

One fact which has emerged from six field-trips (1972-1978) which I devoted to the study of traditional Tibetan and Himālayan metal statuary (Lo Bue, 1978 and 1981) as carried out today in the workshops of Pātan, in the Nepal Valley, was that Newar sculptors use copper and brass for casting their images by the lost-wax process, almost to the exclusion of bronze. This observation prompted me to establish whether the term "bronze", as frequently used by Western art historians to describe Tibetan and Himālayan metal statues, is correct, and, if so, to ascertain the extent to which true bronze images were produced in the past, not only in Tibet and the Himālayas, but also in northern India. In November 1978 Jim Black kindly analysed for me a 20 cm. high Tibetan image of Ṣaḍakṣarī (Christie's sale catalogue of July 2nd, 1980, p.16, No.67 and Sotheby's sale catalogue of June 29th, 1981, p.10, no.13), attributed by von Schroeder to the 13th century, and this was found to be made of brass. Since then Uhlig (1979) has published a number of analyses of Tibetan and Himālayan images made by Josef Riederer[1] and this volume contains 121 new analyses by Paul Craddock of images and other ritual objects from the British Museum collection and elsewhere.

The following discussion serves as an introduction to the study of the various statuary metals in the context of the economic history of Tibet and Nepal (for a fuller treatment see Lo Bue, 1981, Ph.D. thesis).

There is a persistent myth among art historians that northern Indian statuary is cast in what has been termed "octo-alloy" (*aṣṭa-dhātu*), a compound containing copper, tin, lead, antimony, zinc, iron, gold and silver in varying proportions (Spooner, 1915: 157; Bhattasali, 1972 repr.: xx; Saraswati, 1962: 28; Sahai, 1977: 233; Bhattacharya, 1979: 146). This belief has not been supported by any serious study of the results of metallurgical analyses. Lee (1967: 47), commenting on the metallurgical analyses of one Kashmiri and one Indo-Tibetan image, notes that "the parts of the mix are radically at variance with those prescribed by various ancient holy texts for the guidance of artisans. In these, unfounded theory takes precedence and we are given imaginary formulae for particularly auspicious combinations of metals based on numerical magic but certainly incapable of producing the desired effect". The *aṣṭa-dhātu* is not the only instance of the Indian alchemical fascination with magical numbers. Majumdar (1926: 462) also mentions *navaloha*, *saptaloha* and *pañcaloha*.

One of the most striking features about Tibetan and Himālayan statuary, which becomes apparent when studying its materials and techniques, including the use of the lost-wax process and fire-gilding, is that descriptions of these processes appear to belong entirely to an oral tradition, as practised by the artisans and sculptors, as opposed to a religious and academic tradition of *literati*. The latter did not always have a clear picture of the technicalities faced by artists and wrote, as is the rule in Buddhist literature, in order to accumulate personal religious merit rather than to give precise instructions on technical problems. Thus no Tibetan or Newar manuals written in the vein of Cennino Cennini's *Il Libro dell'Arte*, have ever come to light. The suggested existence of a treatise allegedly used by Newar sculptors (Krishnan, 1976: 29 and Bhattacharya, 1979: 67) is without foundation and none of the leading Newar metal sculptors who were repeatedly interviewed during my fieldwork in Nepal had ever heard of such a manual. Attempts to trace Tibetan and Himālayan statuary traditions to literary sources are doomed to failure as the sculptors are sometimes illiterate and certainly ignorant of Sanskrit and do not need to refer to handbooks in order to carry out their work, any more than their western counterparts.

In the light of the above considerations, a study of Tibetan and Himālayan metal statuary has been attempted from a scientific angle, though without neglecting the literary and oral sources. This kind of interdisciplinary approach requires not only the study of the language and literature, but also fieldwork and close collaboration with scientists, so that the evolution of style and iconography in art can be related to the material culture and economic history of the people who produced it.

The traditional attitude of archaeologists and art historians towards the study of northern Indian metal statuary and its technology has not shed much light on the composition of the alloys used in the past. In his study on Taxila Marshall (1951, II: 564) uses the word "bronze" to include alloys other than those of copper and tin, and Goetz (1969: 139), while accepting the fiction of *aṣṭa-dhātu*, adds to the confusion by equating it with brass. The latter appears to regard brass as a "cheap metal", and his prejudice against the term "brass" is derived from the Western classical tradition which regards bronze as the statuary metal *par excellence* and brass as a cheap "substitute".

A detailed study of the metallurgical data reported by Spooner (1915: 157), Marshall (1951, II: 567-569), Lal (1956: 55-56), Lee (1967: 51, n.22), Sahai (1977: 234-236), Werner (1972: 184-187 and 190-191) and Uhlig (1979: 66-67) shows that in northern Indian metal statuary unalloyed copper was used from the times of Taxila, and that brass tends to replace bronze as one proceeds westward from Bengal (an area close to tin-producing countries such as Burma and Malacca) to Rajasthan (where zinc ores were exploited in ancient times: Brown and Dey, 1955: 163 and Werner, 1972: 161-2) and Kashmir. This is of great importance for the study of Tibetan and Himālayan statuary which was, and is, almost exclusively cast or embossed in copper or brass. Copper and zinc ores are found in both Tibet and Nepal, whereas tin is absent from both countries.

Indian statuary was introduced into Tibet from the west (Kashmir) and from the south (northern India via the Nepal Valley) concurrently with Buddhism. During the 10th and 11th centuries western Tibetan Buddhist kings were in contact with Kashmir and other Buddhist centres in India. At their request the Tibetan scholar Rin-chen-bzang-po (A.D. 958-1055) travelled three times to Kashmir and once to eastern India (Snellgrove and Skorupski, 1980: 90 and 99) and, having brought back to western Tibet thirty-two artists in c. A.D. 1019 (according to my calculations; see Snellgrove and Skorupski, 1980: 91, n.21 and 22; and Tucci, 1933, II: 67 and 12), he had chapels and temples built in twenty-one different places. In one of these temples, he erected forty-five metal images, some in copper and some in brass (Tucci, 1933, II: 69; *cf.* Snellgrove and Skorupski, 1980: 94 and 107). Previous to that, Rin-chen-bzang-po commissioned the Kashmiri artist Bhidhaka to make "an image of Avalokiteśvara to his father's size" with brass begged for in Kashmir (Snellgrove and Skorupski, 1980: 32). It is possible that, being an alloy commonly used in Kashmiri metal statuary, brass was preferred for casting statues in western Tibet, although another text unequivocally indicates that copper was also used there (Padma-dkar-po, 1973, I: 30-2; see below, p.42) at the turn of the 10th century to cast images meant for gilding. Copper and brass are also mentioned as the materials of a number of religious items listed in Rin-chen-bzang-po's biography (Snellgrove and Skorupski, 1980: 108). Thus both brass and copper were used in western Tibetan metal statuary from an early period.

A starting point for the discussion of western Tibetan metal statuary and statuary metals is the 98.1 cm high Cleveland Buddha, whose brass alloy was found to contain 68.3% copper, 20.2% zinc and 11.0% lead. It is inscribed as being a "vow of the prince-monk Nāgarāja", who lived in the 11th century and belonged to the lineage of western Tibetan kings. This image has been discussed at length elsewhere (Lo Bue, 1981 Ph.D.

thesis) and it is sufficient here to say that, in the light of genealogical evidence, the Cleveland Buddha should be attributed to the 11th (Karmay, 1975: 29) rather than the 10th (Pal, 1975: 100) century. This masterpiece proves once again the persistence and resurfacing of styles, which I find characteristic of Tibetan and Himālayan art, where copying is the rule, rather than the exception (Lo Bue, 1981: 115 and 126 n. 9). It is the earliest datable image from Tibet, for which metallurgical data have been published. Another early (11-12th century, see below p. 70) example of western Tibetan brass statuary is the 69.3 cm. standing Vajrapāṇi cast with the lost-wax process (Hours, 1980: 95-98), at the Musée Guimet (MA.3546). Western Tibetan statues belonging to the following period (12th-15th century, nos. 42, 63 and 64 on pp.105-6 and below) are cast in brass with small percentages of lead, tin and arsenic. An exception is the stand of no. 42, which has no zinc in its alloy.

Central Tibetan kings were in contact with India and the Nepal Valley from at least the reign of Srong-brtsan-sgam-po (A.D. 627-649), who married a Newar princess. Newar sculptors worked in Tibet from that period onwards, which may explain why central and southern Tibetan metal images are often cast in copper, a favourite metal for Newar statuary owing to the presence of copper ores in Nepal (see below, pp. 37 & 39) and because of its advantages for fire-gilding, which is traditional in the Nepal valley. However, brass was also used in central and southern Tibetan lost-wax metal statuary (see below, p.48), as well as in the Nepal Valley.

Whereas early Sino-Newar images made during the Mongol overlordship (A.D. 1207-1368) were cast in copper (*cf.* Uhlig, 1979: 168, fig. 95), eastern and Sino-Tibetan metal statuary from the Yung-lo period (A.D. 1403-1424) and Hsuan-te period (*cf.* Uhlig, 1979: 220, fig. 136) through to the Ch'ien-Lung period (A.D. 1736-1795) and afterwards was almost invariably cast in brass, even when it was destined for fire-gilding. (see nos. 91; and 5-7, 27-28, 49-52, 86-88, 111-112 in the list on pp.26-31).

Thus the geographical distribution of the use of metals in Tibetan statuary appears to reflect an increase in the use of copper at the expense of brass when proceeding from the west and east towards the centre and south of the country. In the Nepal Valley, where copper was the predominant alloy, there was a general increase in the use of brass from the 18th century onwards, probably in connection with the production of metallic zinc for brass-making and the availability of both zinc and brass from the East India Company (see below, p. 47).

In September and November 1980 I carried out a survey of Tibetan and Himālayan metal statuary in the major public collections of Britain with the aim of producing statistical data on the types of alloy and manufacturing techniques used in Tibetan metal statuary. In this connection I must acknowledge the help received from the British Academy in the form of a grant which enabled me to gather the following data and prepare them for publication in this paper. Of the 378 free-standing statues examined, 331 were of metal, the remaining ones being wood, stone, clay, *papier-mâché* and ivory. As it was not always possible to distinguish with certainty betwen Tibetan and Nepalese images, owing to the activities of Newar sculptors in all parts of Tibet for many centuries, some results in Table 1 on the following page are given as maximum and minimum, according to whether borderline cases are included or ignored. This table only refers to Tibetan metal statues, Newar icons having been left out when positively identified as such.

The general picture which emerges from this survey has been confirmed by the analyses of five Tibetan images at the Victoria and Albert Museum, which were made of brass or copper, by the analyses published by Uhlig (1979) and by those of Craddock (see above, pp.26-31). The results of the metallurgical analysis of one Gandhara and four Tibetan images carried out by A. Martin, of the Victoria and Albert Museum, in September 1980, confirm

Table 1

	Total	Brass	Copper	Silver	Fire-gilded brass	Fire-gilded copper	Cold-gilded	Repoussé	Inlaid
Ashmolean Museum	90-99	56-59	39-45	5	42	25	5	3	5
Liverpool County Museum	62-71	35-37	33-40	1	15	16-23	5	3-4	-
Gulbenkian Museum	2	2	-	2	-		-	-	-
Cambridge Museum of Anthropology	8-11	2	5-7	1	-	4-6	-	3	-
Royal Scottish Museum	29-36	18-24	8-9	3-4	6-9	6-7	0-1	1	1
Total	191-219	133-124	85-101	10-11	65-68	51-61	10-11	10-11	6

that brass was used throughout all periods in northern Indian metal statuary and that copper and brass must be regarded as the most common statuary metals in Tibet. I take here the opportunity to thank both Mr Martin and Mr John Lowry for allowing me to publish these results in Table 2.

It may be concluded, therefore, that copper and brass have been predominantly used in Tibetan and Himālayan metal statuary almost to the exclusion of bronze, although images were occasionally cast or embossed in other metals. The unusual composition of no.4 in Table 2 is discussed below (p.43).

Individual metals: the literary evidence

Copper

Zangs, *zangs-dmar*, and sometimes *li-dmar* and *zi-khyim* are the Tibetan terms generally used to define copper. Copper occupies a pre-eminent position in the metallurgy of India, Nepal and Tibet, where it has been traditionally employed for lost-wax and embossed statuary. *Li-dmar* (red *li*) is mentioned by Padma-dkar-po as being used in northern Indian statuary along with brass, in a passage in which he acknowledges the excellence of the Newar style (1973, 300, ll. 1-2). In view of the initial absence of bronze and white metal and the use of brass and copper in ancient northern Indian statuary it may be surmised that the term red *li* as used by Padma-dkar-po more often than not corresponds to "copper": "*li-dmar* is the same as *raṅ-byuṅ-ljon raṅ-byuṅ-zaṅs* - natural copper" (Dagyab, 1977, I: 52). Pure copper (see no. 37 on p.105), in particular, is very highly thought of (Padma-dkar-po, 1973, I: 294, l.2). The Mongol lay physician 'Jam-dpal-rdo-rje (early 19th century) explains that "native copper from under the earth is as precious as gold: it is rock copper. The native red copper from rock copper is called 'gold copper'. Black copper (cupric oxide ?) is called 'iron copper'" (Chandra, 1971: 41). 'Jam-dpal-rdo-rje's definition of "native copper" casts light on an otherwise obscure term used by the dGe-lugs-pa encyclopaedist Klong-rdol-bla-ma (A.D. 1719-1805; Smith, 1969: 26ff.) which recurs in Tibetan metallurgical literature (e.g. in Padma-dkar-po, I: 300, l.3): "the ore which is dug out like gold is native copper. It has the famous name of 'precious *dzhai kṣiṃ* stone" (Chandra 1973, 1462, ll. 1-2). Klong-rdol (Chandra, 1973: 1462, ll. 3-4) adds that "copper is dug out from parts of Nepal" and makes a distinction between pure Nepalese copper, soft without grooves, and a late poor quality copper of his day, harsh and with many grooves. Copper is found in small deposits in hilly areas of Nepal and has been extracted and also exported from that country to India[2] at least since the 11th century, for the use of Nepalese copper is mentioned in Cakrapāṇidatta's treatise, *Cakradatta*, written in A.D. 1050 (Ray 1956: 108 and 110). In Book V, vv. 42-4 of the late 13th century *Rasaratnasamuccaya* we read: "there are two varieties of copper: the one brought from Nepal is of superior quality" (Ray, 1956: 182).[3] Ray concludes: "on account of its purity Nepal copper was highly valued in old days" (1956: 93-4). According to Ray (1909: 222-3) the best quality copper is also said to come from Nepal in the *Rasāyanaśāstroddhṛti*, a short treatise included in the Tenjur. During his mission in 1793, Colonel Kirkpatrick (1975 repr.: 62) noticed the presence of copper mines in Nepal and reported that, though some of them were nearly exhausted, others were being exploited by a caste of miners. Three years later Abdul Kadir Khan also noted that the Nepalese were working some of their copper mines (Regmi, 1961: 247). The government profits from their annual revenue had been three to four lakhs of rupees, and in those days Nepal must still have been self-sufficient in copper, for the item does not appear in Kirkpatrick's list of principal metal commodities (1975 repr.: 209) exported from the East India Company's dominion to Nepal, either for use in that country or for the Tibetan market. Furthermore,

Table 2

	Inv No.	Description	Origin	Century	%Cu	%Zn	%Sn	%Pb
1)	IS 12-1948	Buddha	Gandhara	5th century	68.45	20.25	3.86	3.62
2)	IS 13-1971	Lama	Tibet	13th?	61.27	31.87	0.74	0.55
	This image is illustrated by Lowry (1973: 34, No. 12) and by Béguin (1977: 242, No. 283), who ascribes it to the 16th-17th century. Results of the analysis of its underside sealing copper sheet:							
					(98.14	—	1.61	0.02)
3)	IM 121-1910	Śākyamuni	Tibet	14th	83.67	0.04	—	0.01
	Illustrated by Lowry (1973: 14, no. 2)							
4)	IM 20-1929	Lama	Tibet	14th/15th	89.28	4.96	7.32	3.10
5)	IM 61-1929	Mahāsiddha	Tibet	18th	70.67	20.89	3.99	5.41
	Illustrated by Lowry (1973: 32). This fire-gilded Sino-Tibetan image was originally attributed by Lowry (1973: 33, no. 11) "possibly" to the 16th-17th century.							

copper was still being exported from Nepal into Tibet, in the late 18th century (Turner, 1800: 382).

Klong-rdol's indication of copper as a metal of Nepalese origin is also confirmed by Orazio della Penna (A.D. 1730, in Markham, 1879: 317) and supoorted by Buchanan's mention of about forty copper mines and sites in Nepal,[4] of the export of "large quantities" of copper to India (Buchanan, 1819: 272), and of the use of Nepalese copper both in Nepal and in Tibet. Again, Hodgson (1972 repr.: 119) noted that "Nepal is full of fine copper, and supplies copper currency to the whole tract" and that copper pots and the like were exported from Nepal to India. In the 18th century copper from the northern areas of Nepal was traded in the Terai (Regmi, 1971: 20) but by the end of the century, copper production in Nepal was barely enough for home consumption. From 1800 all existing mines in Nepal were brought under direct governmental management and arrangements were made to purchase copper on a monopoly basis. Indeed, Kirkpatrick had already noticed that "European copper was procurable in Calcutta" for one rupee the seer less than Nepalese copper. Kirkpatrick (1975 repr.: 176) had a poor opinion of Nepalese mining expertise and noticed the "backwardness of the natives in the arts of mineralogy and metallurgy". Buchanan (1819: 76-7) reports that "the ore is dug from trenches entirely open above, so that the workmen cannot act in the rainy season, as they have not even sense to make a drain". Nevertheless, the trade obviously continued in spite of the facts that not only the export of copper, but even private trading had been banned and stringent methods adopted by at least 1813 to stop it being smuggled out of the country (Regmi, 1971: 219). Tibetan merchants continued to buy copper utensils in Kathmandu (Buchanan, 1819: 213 and 232).

Copper appears as an import in Nepal only at the turn of the 19th century (Lévi, 1905, I: 312). By the early 20th century Nepal had to import "sheet copper and other metals" from British India (Imperial Gazetteer of India, 1908: 121) and there is reason to believe that by the end of the 19th century Nepalese copper mines were exhausted or uneconomical to work, and that very little copper is mined in Nepal nowadays.

Copper used by 20th century Newar artists is now bought in sheet form through the London metal exchange and is mixed with any scrap copper they may lay their hands on, such as old wire, faulty castings, sprues from previous images, and so forth. The vast majority of so-called Nepalese "bronzes" are in fact fire-gilt copper images, made by Newar artists, for the use of almost pure copper in Newar statuary is very ancient, as has been pointed out by Kramrisch (1964: 30). Copper is still very much in demand amongst Newar sculptors for the casting of good quality statues (nos. 116-119), in spite of the problems that its high melting point (1083°C) poses for the comparatively primitive Newar metallurgy. The soft surface of pure copper is easier to chase than the hard and brittle surface of brass, and it does not present any problems for fire-gilding.

Although Tibetan sculptors had alternative supplies of copper to those from Nepal, it is likely that Nepalese copper continued to reach Tibet in one way or another during the 19th century for, as a rule, Tibetans themselves did not get involved in mining on a large scale. They feared upsetting the local gods of the earth. and preferred to import metals from India,[5] China, Nepal, and East Turkestan. To that effect Hedin mentions Csoma de Körös's native source on the matter, dating from a few years before 1834:

> Mines are rarely excavated in Tibet. In the northern part of Nari (*sic*), and in Guge, some gold dust is gathered, as also in Zanskar and Beltistan (*sic*) it is washed from the rivers. If they knew how to work mines, they might find in many places gold, copper, iron and lead.
>
> (Hedin, 1922, VII: 185).

Ordinary Tibetans have religious and economic objections to the exploitation of mines. In Tibet

> there is an old-established objection to mining on religious grounds. 'If minerals be taken out of the ground', says the ordinary Tibetan, 'the fertility of the soil will be weakened'. Many think that the minerals were put into the ground by the 'Precious Teacher', Padma Sambhava, when he brought Buddhist teachings from India, and that, if they are removed, rain will cease and the crops will be ruined. The religious objection is intensified by an economic one. When a mine is found, the local peasants and others are expected to work it without pay. This work being for the Government, the system of *ula* (unpaid labour) is held to apply. So the villagers have every incentive to conceal the existence of mineral wealth, and will sometimes turn out and attack those who try to exploit the mine.
>
> (Bell, 1968 repr.: 110-111).

The Tibetan administration, on the contrary, was interested in developing the mineral wealth of the country (Bell, 1927: 158-9; *cf.* below, p.55). The presence of copper ores in Tibet was first reported by the Italian Capuchin, Father Orazio della Penna di Billi (A.D. 1730, in Markham, 1879: 317) who spent twenty years in Tibet and later, in A.D. 1783, by Saunders, who accompanied Captain Turner to Tashilhunpo, near Shigatse (Turner, 1800: 405). Turner (1800: 296) himself mentions "mines of lead, copper, cinnabar and gold" on the roads to Ladakh and Kashmir and specifies that "copper mines furnish materials for the manufactory (*sic*) of idols, and all the ornaments disposed about the monasteries, on which gilding is bestowed" (Turner, 1800: 372). Copper mines, as well as silver and gold mines, were mentioned also by Hedin's informants (Hedin, 1922, IV: 99), and copper is found in Ladakh (Hassnain, 1977: 43) and in Zangskar (Marshall, 1951, II: 565 and 570). Deposits of malachite and azurite (basic copper carbonate) are known to exist in sNye-mo-thang, a site probably in the hills south-west of Lhaşa (*cf.* Pal, 1969: 30), though arbitrarily placed by Ronge (1978: map) somewhere between Gyantse and Rin-spungs. Because of their importance, "the Lhasa government strictly controlled" their "mining and distribution", which supplied most of the green and blue pigments used by Tibetan painters (Jackson, 1976: 274). The central Tibetan administration mined the colourful minerals only once a year, apparently so as not to exhaust the supply, but the people of sNye-mo also picked up loose bits on the mining site in order to sell them for their own gain (Ronge, 1978: 148). 'Jam-dpal-rdo-rje specifically mentions "malachite" (Tib.:*spang*) and "azurite" (Tib.:*mthing*) in his section dedicated to copper ores (Chandra, 1971: 57): "they appear in the earth which has malachite and azurite (...) By melting them there appears copper. It is the one which is called 'naṭive copper'".

The existence of copper, besides iron, zinc, lead and a wealth of other minerals, was also reported during the surveys carried out by investigation teams despatched to Tibet by the Geological Section of the Chinese Academy of Science in 1957 and 1964-1965. Copper also occurs in the northern foothills of the Kunlun between Yarkand and Khotan, and bronze and brass items from east Turkestan dating from the 7th century (Werner, 1972: 190-3, table 7.1) are known. Copper mines in eastern Tibet are mentioned by Cooper (1871: 463-4, *cf.* Pranavānanda, 1939: 37). For a long time, copper has been extracted to the south of Li-thang (Gong-kha-gling; Coales, 1919: 246 spells this place name "Kungkaling") and near 'Ba-thang (Le'), in eastern Tibet (Ronge, 1978: 145). It is worth noting that "one of the most important areas for metal casting is the province of Kham in eastern Tibet. Three well-known centres in the province are Derge, Chamdo, and Reo-Chi" (Pal, 1969: 29). The coppersmiths of sDe-dge, famous throughout Tibet (Rockhill, 1894: 358), also got their raw material from Gong-kha-gling, south of Li-thang, (Coales, 1919: 246) and so probably did those of Li-thang (Rockhill, 1891: 207). Copper ore was also found in the area of sDe-dge itself (*cf*. Duncan, 1964: 19). At Va-ra-dgon-pa, a copper "mine was opened in 1910 or thereabouts, but has since been closed" (Coales, 1919: 246). Although copper ore was worked in the neighbourhood of Zi-ling, on the Sino-Tibetan border, most of the copper objects in eastern Tibet and Amdo were imported from China. For example, at Lhamdun, south of 'Ba-thang, Rockhill (1894: 340) "noticed in use (...) a good many Chinese utensils, especially of iron and copper". As the most important copper deposits lie in eastern Tibet, and those in lower sPo-bo (on this district, see Waddell, 1906: 440 and 502-3) played no great rôle, central Tibetans occasionally obtained their copper from Khams (Ronge, 1978: 146). Sometime between 1851 and 1853, rDo-rje-don-grub of sKyid-stod "was sent to Khams to procure the copper necessary for the repairs at bSam-yas" (Petech, 1973: 91). However, it is certain (see above p.39) that the metal continued to be imported into Tibet through its southern borders (Ronge, 1978: 145), sometimes for minting purposes (McGovern, 1924: 342). Although copper ores were apparently worked in Bhutan for the manufacture of large copper cauldrons (Pemberton, 1961 repr.: 75), that country too had to import the metal (Pemberton, 1961 repr. : 77).

In Tibet, copper has been used either pure, or to form the various alloys which go under the general terms of *li*, *'khar-ba* and *khro*. The 'Brug-pa bKa'-rgyud-pa scholar and artist Padma-dkar-po (A.D. 1526-1592) informs us that during the reign of Srong-brtsan-sgam-po native copper, *li-dkar* (white *li*) and *li-dmar* (red *li*) were used "pure", and also in composite metalwork (inlaid patchwork; Padma-dkar-po, 1973, I: 300, 1.3), and that during the reign of Ral-pa-can (A.D. 815-836) copper was used not only to inlay the lips of metal images, but also in their alloys, whereby "they gradually turned darker than the early ones" (Padma-dkar-po, 1973, I: 301-2). From the early 11th century, native copper was used in western Tibet either pure (Tucci, 1959: 186) or alloyed with zinc to cast metal images (see above, p.34). Finally, mention should be made of the use of copper in Tibet from at least the 11th century (see above, p.34) to cast various ceremonial articles, including reliquary *stūpas* (no. 46 on p.105 below).

Zi-khyim

Sarat Chandra Das's *A Tibetan-English Dictionary with Sanskrit Synonyms*, (1976 repr.: 1090) contains the following translation and explanation under the Tibetan word *zangs:* "copper - pure unalloyed copper being considered very valuable, images of Buddha and *Bodhisattva* made of pure copper are called *nor-bu dzha-kṣiṃ* (*sic*); also a compound of gold, silver, copper, zinc, or of mica, quicksilver, tin and lead (....)". The most famous statue in Tibet, the Jo-bo (Lord) of Lhasa, portraying a more than life-size (Walsh, 1938: 538) Śākyamuni, is said to be made of such an alloy (Tucci, 1959: 181-2; Dagyab, 1977, I: 52). Although the image is said to have been brought from China by Srong-brtsan-sgam-po's Chinese wife, the statue is supposed to have been originally made in India from "gold, silver, zinc, iron, and copper". (Das reported by Walsh, 1938: 539. See also Landon, 1905, II: 310). On these and stylistic grounds, Walsh (1938: 539) concludes that "the image is Indian". It is to enshrine this image that king Srong-brtsan-sgam-po built the Jo-khang during the second quarter of the 7th century. It may be interesting to contrast Walsh's statement with the tradition that the Jo-khang itself was built by Newar craftsmen to house "several valuable Buddhist images" brought to Tibet by Srong-brtsan-sgam-po's Newar queen as part of her dowry (Norbu and Turnbull, 1972: 143) and that its gilt copper "screen was, perhaps, the work of the famous Nepalese artist and craftsmen, Anika (or Aniko) who worked also in China in the latter half of the 13th century "(Richardson, 1977: 169; Richardson does not give any reason to justify his attribution).

On the other hand Padma-dkar-po (1973, I: 300, 1.3) states that *zi-khyim* was used in Tibetan statuary at the time of Srong-brtsan-sgam-po, along with "pure" red and white *li* for composite inlaid metalwork (Tib.: *sho-bsgrigs*, translated by Dagyab (1977, I: 55 and 57) as: "square patches" and "square pieces". This type of inlay work may perhaps be exemplified by a 17th century brass Ṣaḍakṣarī in the British Museum (registration no. 1905.5-19.7). The anonymous text translated by Tucci (1959: 186) confirms that *zi-khyim* was used to manufacture statues which were subsequently gilded during a period corresponding to the 10th-11th century in western Tibet, and Padma-dkar-po (1973, I: 301-2) confirms that:

> Regarding the varieties (of early Tibetan images) at the time of the two monk-princes, uncle and nephew (Ye-shes-'od and Byang-chub-'od).
>
> They were mixtures of red copper (Tib.: *zangs-dmar*, i.e.) *zi-khyim* thickly coated with gold from Zhang-zhung (western Tibet. On Zhang-zhung and its extension see Tucci, 1956: 71ff.).
>
> Their nose is beautiful and the shape of their body sturdy.
>
> Their *déhanchement* has a graceful manner. Those which resemble the images of Nepal are called *mthon-mthing-ma* (perhaps not in the sense of "having their hair raised up and of a blue colour" as suggested by Tucci, 1959: 186 followed by Karmay, 1975: 7, but with reference to the fact that they were made in or for the royal monastery founded by Ye-shes-'od at mTho-lding, a place-name whos various spellings include that of mThon-mthing, as found in the rGyal-rabs gsal-ba'i me-long; cf. Kuznetsov, 1966: 198; Tucci, 1933: 64).

How do the two Tibetan words, *dzhai-kṣiṃ* and *zi-khyim* relate to each other, and in which context do they appear in Tibetan literature? In view of the facts that the Jo-bo itself is said to be made of *dzhai-kṣiṃ* and that *zi-kyim* was used in western Tibet in connection with gilding at the time of the second introduction of Buddhism into the country, an attempt to translate and interpret these two words appears to be useful for the purpose of shedding more light on the use of statuary metals in early Tibetan sculpture.

Das (1976 repr.: 1090) identifies the Tibetan transliteration "*dshai-kṣiṃ*" (*dzhai-ksim* in the standard system of transliteration followed by me), with the Sanskrit *yaukṣiṃ*, a term which I cannot find in any Sanskrit dictionary, and he does not include the word *zi-khyim* in his dictionary. In his work on Tibetan loan-words, Laufer (1918: 55) only mentions *zi-khyim* and postulates a Sanskrit etymology with a question mark, but Tucci (1959: 180, n.2) suggests a Chinese derivation, from the Chinese *ch'ih chin* (Mathew, 1969: 145, 1048: "deep coloured gold; copper") and gives the spellings "*ji k'yim*" (*ji-khyim*, in the transliteration system I follow) and "*dsai kṣiṃ*" (from Klong-rdol who, however, has *dzhai-kṣiṃ* in the standard transliteration system I follow). Dagyab (1977, I: 51-2) only uses the form *dzhē-kṣiṃ* to the exclusion of any other, perhaps following his source, 'Jigs-med-gling-pa (A.D. 1729-1798). As will appear below, each of these words is used to the exclusion of all the others in Tibetan texts dealing with metals, and they should be regarded as various spellings for the same term. I have chosen to follow the spelling *zi-khyim* as consistently used by Padma-dkar-po (A.D. 1526-1592), not only on the grounds that he is the earliest and more detailed of my Tibetan sources, but also because he was a well-known artist himself besides being a *literatus*, and 'Jig-med-gling-pa's account used by Dagyab is in fact largely drawn from Padma-dkar-po's.

According to Padma-dkar-po (1973, I: 264, ll. 5-6) *zi-khyim* "appears like the gold on the banks of the Sin-dhu river; it is therefore called 'red gold'" and it is recognized precisely by its red colour. It emits the light of a rainbow: when touched by acid, it shows the very bow of Indra", i.e. it becomes iridescent. Klong-rdol (Chandra, 1973: 1462, ll. 1-2) distinguishes two types of *zi-khyim: li-khra* ("iridescent *li*"), whose ingredients, "gold, silver, copper, and white iron, and rock crystal, lead, black and white (*zha-nye dkar nag*), and mercury, the eight of them, when melted and ground, are known as 'artificial *dzhai-kṣiṃ*'"; and the "precious *dzhai-kṣiṃ*" (Tib.: *nor-bu dzhai-kṣiṃ*), which is "native copper dug out like gold underneath the earth". The composition of the *li-khra* type of *zi-khyim* as described by Klong-rdol differs from that given by Das, for Klong-rdol does not mention the presence of zinc and tin in the alloy. Elsewhere, in the same dictionary, Das (1976 repr.: 1212) maintains that *li-khra* is "a compound made of gold, silver, zinc and iron cast together", a most unlikely mixture in which copper is not mentioned, and which again is in disagreement with the definition given by Klong-rdol, whose text Das generally follows.

Following 'Jigs-med-gling-pa, Dagyab (1977, I: 51-2) states that pure *zi-khyim* "is obtained from the earth and greatly resembles natural copper" and that it turns iridescent when touched by a poisonous "water" (i.e. acid). He distinguishes it from "artificial" *zi-khyim*, "an alloy composed mainly of copper mixed with gold, silver or other precious metals, and nickel silver". He confirms that *li-khra* is nothing else than artificial *zi-khyim* and that the Jo-bo in the Jo-khang is made of this alloy. Dagyab (1977, I: 51) goes as far as identifying one particular image as being made of pure *zi-khyim* and even illustrates it. Unfortunately, throughout his work, Dagyab never supports his descriptions with metallurgical analysis, thus adding very little to our knowledge of Tibetan statuary metals.

Neither native nor artificial *zi-khyim* is mentioned in 'Jam-dpal-rdo-rje's comprehensive *Materia Medica of Āyurveda*, thus making it difficult to postulate a Sanskrit origin for the word and suggesting that Tucci's etymology is more satisfactory. However, it may be interesting to investigate a possible connection between this word (pronounced: Sikhim) and the place name Sikkim, where copper mines are known to exist (see below, n. 2; Waddell, 1906: 72 and 491; and Marshall, 1951, II: 571).

Although it may be assumed that Tibetan scholars writing on the subject of *zi-khyim* and *li-khra* did not know their chemical composition and were merely following either hearsay information or a mixed academic tradition partially traceable to Chinese and Indian sources, all Tibetan authors so far reviewed appear to agree at least in one respect, that both pure and artificial *zi-khyim* are copper alloys. None of them mentions zinc (Tib.: *ti-tsha*) or tin (Tib.: *gsha'-dkar*) among the ingredients of artificial *zi-khyim*. It should be mentioned, however, that Jäschke (1972 repr.: 471) equates the Tibetan term *zha-nye dkar-po* "white lead", with *gsha'-dkar*, "tin", thus allowing another interpretation of Klong-rdol's formula.

Tibetan metal (*li*) statues showing an iridescent (*khra*) surface are rare. I have come across only one statue with this appearance which has been analysed, a late 14th or early 15th century portrait of the Pan-chen Phyogs-las-rnam-rgyal from Bo-dong (A.D. 1306-1386). Its metallurgical analysis (see above, p.38,no. IM 20-1929) shows that copper, tin, zinc and lead are present in significant proportions in the alloy. In fact this is a very rare instance of a Tibetan image actually cast in a kind of bronze alloy. It might be suggested that the Tibetan expressions "artificial *zi-khyim*" and *li-khra* cover some unusual or seldom used Tibetan copper alloys, or else that they are the Tibetan equivalent of the Indian *aṣṭa-dhātu*, as suggested by Tucci (1959: 180), and thus a mythical alloy (see above, p. 33). The fact that the Jo-bo of Lhasa is said to be made of this alloy by Tibetan sources and the circumstance that no Western visitor has ever been able to have a proper look at the material of the image, which is heavily covered with clothes and bedecked with jewellery, should make us cautious, if not suspicious, with regard to the alloy as described by

Tibetan writers. However, it is more likely that *li-khra*, or artificial *zi-khyim*, is just a kind of leaded brass. This suggestion is reinforced by Dagyab's statement that at the time of Ye-shes-'od and Byang-chub-'od (see p. 42) many statues were cast in that material. We know (see p. 34) that western Tibetan statuary of the 10th-11th centuries was cast in brass, besides copper, which is also mentioned by Dagyab as being used at that time. When Dagyab (1977, I: 56) adds that "the *li-khra* statues of this period were of such fine quality and resembled so closely the Indian statues as to be easily mistaken for them", I cannot help thinking of the Cleveland Buddha, which was cast in leaded brass (see above p. 34) in Kashmiri style, perhaps by Kashmiri sculptors working in western Tibet or by their Tibetan pupils, during the 11th century.

With regard to the "pure" or "precious" i.e. native type of *zi-khyim*, we know that Padma-dkar-po equates it with *li-dmar*, red *li*, which I have suggested to be copper (see above, p. 37) and which Dagyab (1977, I: 52) also describes as "natural copper". The anonymous text translated by Tucci equates it with "red copper, *ji k'yim*" (Tucci, 1959: 186); Klong-rdol defines it as "native copper"; 'Jigs-med-gling-pa states that it "is obtained from the earth and greatly resembles natural copper" (Dagyab, 1977, I: 51); and Das (1976 repr.: 1090) specifies that Buddhist images made of pure unalloyed copper are called precious *zi-khyim*. In this connection it may be interesting to note that there is an important copper ore, bornite or erubescite ($Cu_5 Fe S_4$ or $Cu_3 Fe S_3$) which, on account of its peculiar colour and iridescence, is known as "peacock ore", "pure copper ore", and "horseflesh ore". The colour of a freshly cut surface of bornite is coppery, but in moist air this rapidly tarnishes to iridescent blue and red colours. According to Holland "it occurs in several parts of India" (Ray, 1903, I: 76), and the presence of sulphur in some of the copper objects found at Taxila was noticed by Ullah (Marshall, 1951, II: 570). In the light of the above literary and metallurgical evidence, there is strong indication that pure *zi-khyim* is nothing other than native copper, and that red *li* is yet another one of the many Tibetan expressions used to indicate copper. In connection with the use of these three terms by Tibetan authors to define one western Tibetan statuary metal, it is important to note that Ullah (Marshall, 1951, II: 570) reported the existence of a native copper of a very high degree of purity in Zangskar (literally: "White Copper") a culturally western Tibetan area. The analysis of a specimen of Zangskar copper made by Ullah gave the following result: 99.4% Cu, 0.081% Fe and 0.34% insol. (SiO, etc.). It is very likely that similar ores of native copper of very great purity (*nor-bu zi-khyim*) were used by the western Tibetan kings for casting the images mentioned by Padma-dkar-po, by the text studied by Tucci, and by Dagyab's sources, and that they were also used in alloy with zinc to cast at least some of the early brass images from western Tibet, at the time of Rin-chen-bzang-po. We have already seen (above p.40) that copper ores are also found in Ladakh, where Rin-chen-bzang-po was active during the first half of the 11th century.

Zinc

Zinc (Tib.: *ti-tsha*), like tin, is not used as a statuary metal on its own, but is always alloyed with copper. The history of zinc metallurgy is dominated by the fact that its oxide is not reduced by carbon below the boiling point of the metal. If zinc oxide ore is heated to boiling point (above 906°C) without special precautions, it simply evaporates into the atmosphere. In England, it was not until A.D. 1738 that William Champion first obtained patent protection for a furnace fitted with an external condenser for the production of metallic zinc. However, Ray (1956: 138 and 171) provides sufficient literary evidence to conjecture that zinc had been isolated by Indian alchemists from at least the 12th century (see below,

p. 46 and nn. 8 and 9).

The problem of tackling the time and place of the recognition and production of metallic zinc is directly connected with the manufacture of brass. Until zinc was isolated and produced on an industrial scale, brass was manufactured by heating zinc ore (calamine) with thin plates of copper, which would absorb the zinc metal *in statu nascendi*. Champion's experiments in the 18th century and Werner's in the 20th showed that brass manufactured by this method could contain no more than 28% zinc. Hence, a zinc content above 30% is a sure indication that the brass in question has been obtained from metallic zinc and copper.

This circumstance is important, for ascertaining the period and area of the first production of zinc metal would help to establish a *terminus post quem* for those brass images with a zinc percentage exceeding 30%. Conversely, a dated image with more than 30% zinc in the alloy would cast more light on the history of the metallurgy of zinc. Since metallurgical analysis reveals that brass was used traditionally in northern Indian and Kashmiri statuary and was adopted from at least the 11th century in western Tibet for casting images, it may be useful to look for historical evidence of the production of zinc and brass not only towards India but also towards the "brass country" (Needham, 1974, V/2: 220), Iran, with which Tibetans traded from at least the 8th century (Beckwith, 1980: 35 and al Ya'ḳūbī, 1937: 4 and 234-6).

During his stay in Iran, Marco Polo (A.D. 1254-1324) witnessed the process of making "tuzia" (tutty, impure zinc oxide) from an ore which he describes as *andànico* [6] and which we can reasonably assume was calamine. *Tūtiyā* is the Middle Persian word for calamine, which spread into Arabic and most Western Languages (Needham, 1974, V/2: 203).

> They take the crude ore from a vein that is known to yield such as is fit for the purpose, and put it into a heated furnace. Over the furnace they place an iron grating formed of small bars set close together. The smoke of vapour ascending from the ore in burning attaches itself to the bars, and as it cools it becomes hard. This is the tutty; whilst the gross and heavy part, which does not ascend, but remains as a cinder in the furnace, becomes the spodium.
>
> (Masefield, 1936: 71).

In his *Cosmography* (c.1200) the Persian al Kazvini describes the scraping of tutty from the sides of the furnace (Dawkins, 1950: 5). Again, Marco Polo mentions "a mountain where the mines produce steel and also andanico" in the district of "Chingitalas" (Ponchiroli, ed., 1979: 49) in Turkestan.[7] Zinc deposits have been located in the Khotan district, and references "found in sixth century texts" as well as "archaeological finds at Kucha in Khotan show the way" by which knowledge of brass-making with zinc ore "penetrated from Persia" (Forbes, 1971, VIII: 281). We have seen (above, p.40) that copper ores exist between Khotan and Yarkand. It is quite significant that Needham (1974, V/2: 220, n.c) should conclude his section "The origins of zinc" by stating that Chinese mention of

> brass as a Persian export would point to the Iranian culture-area as the place where we ought to look, but unfortunately the early history of science and technology in that region is still (...) poorly documented (...) All in all, nevertheless, we are disposed to favour the view that brass-making began in the Persian culture-area and spread both west to Europe and east China
>
> (Needham, 1974, V/2: 220 and n.c.).

In any case, it would seem that the recognition and production of metallic zinc had started in India by the 13th[8] and in China by the 15th centuries (Needham, 1974, V/2: 213 and 211, table 98).

In 1597 Libavius (c. A.D. 1545-1616) received Indian zinc, which he called "Indian or Malabar lead" or "Malabar tin" from Holland. He was uncertain what it was but ancient lead-zinc deposits "which according to the information of Carus must have already been exploited around 1382" (Werner, 1972: 127) exist near Jawar (or Zawar) "15 miles due south of Udaipur, Rajasthan" (Brown and Dey, 1955: 163). There are also remains of zinc furnaces at Sojat in Jodhpur and in connection with the manufacture of brass alloys it is interesting to note that important ancient copper mines existed in Jaipur (*Imperial Gazetteer of India*, 1908, XXI: 128). The zinc mines at Jawar were active through the 18th century until 1812. According to Somerlatte, "very many small clay retorts are found in the ruins of Zawar, which may possibly have been used for zinc production in ancient times" (Werner, 1972: 127). Indeed, it has been suggested that the term "calamine" may derive "from its place of exportation, Calamina, at the mouth of the Indus" (Beal, *Si-yu-ki*, 1884, II: 174, n. 103). Small zinc deposits also exist in Kashmir. In this connection, it may be interesting to note that Ponchiroli (1979: 299) explains *andànico* as (*ferrum*) *indianicum*, "Indian iron", though he translates the term as "antimony" instead of calamine.

Details of the extraction of metallic zinc from calamine are to be found in the *Rasaratnasamuccya*, as translated by Ray (1956: 171). That treatise, which starts with a Buddhist invocation, and is attributed by Ray (1903: 223) and Kala to "about 1300 A.D." merely borrowed the description of calamine and the couplets concerning the extraction of zinc almost word for word from the *Rasaprakāśasudhākara*, a comprehensive work by Yaśodhara who, according to Ray, lived in the 13th century and used as one of his authorities Nāgārjuna.[9] It is interesting to note that by the 15th century, perhaps in connection with the Muslim conquest, alchemy had become so neglected in India that one alchemist, Govindācārya, declared that for the knowledge of certain processes he was indebted to the Buddhists of Tibet (Ray, 1909: lxvii). In this connection, and on the basis of the attribution to the 15th and 16th century of two Tibetan metal images at the British Museum (nos.110 and 98 on pp.108 and 107) it may be tempting to surmise that by the 15th century Tibetans had the knowledge of the need of an external condenser for the extraction of metallic zinc, whether derived from Iran, from Indian alchemical treatises, or from China. However, their very poor mining and technological ability strongly suggests that they either imported the unalloyed metal already smelted (Kirkpatrick, 1975 repr.: 209), or else used local zinc ores, and alloyed them with copper, to manufacture brass. In fact we know from della Penna (A.D. 1730, in Markham, 1879: 317, *cf.* Giorgi, 1762: 456) that Tibetans used the cementation process to manufacture brass from local zinc ores. Della Penna wrote in 1730, at a time when zinc metal had not yet been isolated in Europe, and although he could only recognize its ores, it is quite clear that he refers to zinc when describing a "mineral, of a white colour, like tin, which is called *tikzà*, and is worked into a sort of brass by being mixed with copper". As we know, *ti-tsha* is the Tibetan word for zinc. Also 'Jam-dpal-rdo-rje describes the ores used to make brass: "the one having bluish-white lustre or the cloudy one, with specks (Tib.: *skya-sob*, not in the dictionaries, as translated by Phuntshogs Wangyal) is like *a-rag*. It has hair-clefts. After having been finely ground, it is thrown into molten copper and there appears light-coloured brass. Brass is not produced (from the ore alone)" (Chandra, 1971: 57). In that passage, not only is calamine (smithsonite, sometimes blue but white when pure) recognized as zinc ore, but the cementation process is mentioned too.

The presence of lead and zinc deposits in Tibet was also reported by investigation teams of the Chinese Academy of Science (see above, p. 40) and zinc oxide is mentioned by 'Jam-dpal-rdo-rje as *ti-tsha dkar-po* ("white zinc") in his description of brass manufacture (Chandra, 1971: 43). In the same *Materia Medica*, 'Jam-dpal-rdo-rje describes metallic zinc in the following terms: "as for zinc, it is blue and is like the Tibetan silver appearing from both red and green stones. If you rub it with fodder barley it produces a sharp sound. If you break it, its edge is like *cong-zhi*[10] If it is mixed with copper it turns into brass" (Chandra, 1971: 44). Zinc ores, probably sphalerite and calamine of various colours, are described by 'Jam-dpal-rdo-rje (Chandra, 1971: 58) under the title of "yellow zinc"[11] and associated with lead and silver. The ophthalmic use of tutty from melting of zinc ores is mentioned by 'Jam-dpal-rdo-rje.

The presence of zinc ores and mines in Nepal was reported by Buchanan (1819: 76, 94, 195, 264, 272) and Hodgson (1874: 109): "Nepal produces plenty of zinc, but no skill to work the mines". Furthermore, "little is known of the deposits near Tiplin in Nepal" (Brown and Dey, 1955: 614). Ullah follows Latouche in mentioning that "copper ore associated with that of zinc is common in Sikkim" (Marshall, 1951, I: 571). Hodgson (1874: 119) specifies that there are lead and "Zinc mines in Nepal, but no skills to work them profitably. A deal of each is imported from the plains, and also of Tin, with which last, and with the Zinc got from us, the Nepalese mix their own Copper, and make a great variety of mixed metals in a superior style". Kirkpatrick (1975 repr.: 209) mentions zinc in his list of principal commodities exported by the East India Company to Nepal either for use in that country or for the Tibetan market in the late 18th century and the circumstance is not surprising when we know that by then Europe had started to produce metallic zinc as a separate commodity in commercial quantities.

Brass

Brass (Tib.: *rag, ra-gan*, and some types of *li*) is described in a number of Indian and Tibetan texts for its external properties. Different proportions of copper and zinc give rise to alloys of varying ductility and brittleness and having a range of colours, of which the most notable is that with about 80% copper which resembles gold. Klong-rdol (Chandra, 1973: 1462, ll. 4-5) distinguishes various types of brass: "'female brass' and 'stone brass', which are yellow, (and) have a good ductility; 'male brass' is the brass which makes the 'light yellow' type of brass and is poor." 'Jam-dpal-rdo-rje (Chandra, 1971: 43) tells us that "red, yellow and bright types of brass come from China, one or three parts of copper having been admixed to (one of) zinc. Also, the white one is firmer than silver". Padma-dkar-po (1973, I: 300, l.1) mentions that in northern India images were made of "white *li*, brass, and, being mixed, it was like the light yellow types of brass".[12] Regarding the materials of the "new" images, by which he means the statues cast from the advent of the Ming dynasty (A.D. 1368), "those which are known as *sku-rim-ma* and appear in Chinese brass or in light yellow brass are superior on inspection "(Padma-dkar-po, 1973, I: 304, ll. 5-6).[13] In Tibet itself the images of the period of the first religious king Srong-brtsan-sgam-po when made from brass or *khro* are similar (Padma-dkar-po, 1973, I: 304, l.1), and the composite ones, made with different metals (Tib.: *zangs-thang-ma*),[14] during the reign of Khri(-gtsug-lde-brtsan) Ral(-pa-can) (see above, p. 41) "were not as good as those made of brass" (Padma-dkar-po, 1973, I: 301, l.5).[15] From the 11th century onwards, brass was consistently used in Tibetan statuary, though described by Western scholars as "bronze". A passage in Padma-dkar-po (see below p.50) suggests that the metal images made by Indian artists in central Tibet during the early 9th century were cast in brass and inlaid with copper and silver. In the context of the Indo-Tibetan derivative style which may have resulted from the imitation of

Pāla models in central and southern Tibet, one should perhaps situate nos. 82, 108 and 105-108 which were all cast in brass with 68.5-74.0% Cu and 24.2-28.5% Zn. Their alloys show copper and zinc percentages very close to the proportions in one of the types of brass described by 'Jam-dpal-rdo-rje (see above, p.47) and nos. 106-108 are inlaid with silver and copper. We have also seen (above, pp.34-5), how brass was used in western Tibetan statuary from the 11th century.

The first names of Tibetan artists known to have used brass and mentioned as "most accomplished in the art of sculpting" images in Tibet, are those of the *sprul-sku* Padma-mkhar-pa and Sle'u-chung-pa (Kong-sprul, in Chandra, 1970: 572, 1.5; and Tucci, 1959: 186). Dagyab (1977, I: 38-39) regards them as contemporaries of Tsong-kha-pa (A.D. 1357-1419), but gZhon-nu-dpal (A.D. 1392-1481; Roerich, 1976 repr.: 829) mentions one Sle'u-chung-pa as a disciple of the great translator bSod-nams-rgya-mtsho (A.D. 1424-1482) in western lHo-brag, a southern Tibetan area bordering with north-western Bhutan. Both sculptors were probably active in the mid-15th century. According to Dagyab (1977, I: 56) or his sources, the statues made by Sle'u-chung-pa closely resembled the "new" Chinese (Ming, A.D. 1368-1644) ones, a remark which can be traced also to the anonymous author of the text studied by Tucci, who tells us that the images made of brass or the gilded images[16] by Padma-mkhar-do and Sle'u-chung and other clever artists may be mistaken for the Chinese ones (Tucci, 1959: 186). Both Tucci's and Dagyab's sources describe the style specific to Sle'u-chung-pa, and mention that the "cushion-seat was formed from a double row of lotus flowers completely encircling the seat" (Dagyab, 1977, I: 56), a characteristic to be found , for example on a gilded seated Sa-skya lama published in Christie's sale (catalogue of July 2nd, 1980, p.16, no. 69), which may be attributed to the 15th century.[17]

Brass continued to be widely used in Tibetan statuary until the present century and Turner (1800: 274) was well aware of the types of metals used in the workshops and in the collection of images studied by him in a "gallery" of Tashilhunpo monastery. After mentioning the manufacture of a brass portrait of a deceased *dge-slong*, he goes on to say that "some of those images were composed of that metallic mixture, which in appearance resembles Wedgwood's black ware, but the greater part were of brass or copper gilt." He concludes: "the manufacture of images, is an art for which they are famous in this country. Theshoo Lomboo has an extensive board of works, established under the direction of the monastery, and constantly employed in this manufacture." Some of the images shown to Turner had been brought from China, Lhasa and Nepal. Although we know from della Penna that brass was manufactured in Tibet with local zinc ores, from at least the 18th century brass and brass ware were also imported into central Tibet from Nepal (della Penna, 1730, in Markham, 1879: 317; Regmi, 1961: 247; Buchanan, 1819: 213 and 232; and Sandberg, 1904: 160), whereas eastern Tibet was supplied by merchants bringing in brass ware from Kansu (Teichman, 1922: 86).

In Nepal, brass must have been known and used for various purposes from a very early date. During the administrative organisation of Tibet under Khri-srong-lde-brtsan (A.D. 754-797), one of the four kings paying tribute was the king of Nepal, with the appellation of "king of brass" (Stein, 1962: 20, from dPa'-bo gTsug-lag-phreng-ba's chronicle, written between A.D. 1545 and 1565). However, the preference for copper in early Newar statuary may be explained by its relative abundance until the 19th century, by its prestige, and by its advantages for mercury gilding. The production of brass statuary seems to have flourished particularly after the Gorkha conquest, perhaps for economic reasons following the diminished wealth of the Buddhist monasteries and lack of royal patronage, and certainly in connection with the availability of zinc metal from British India (see above, p.47) coupled with the progressive exhaustion of local copper mines. Hodgson (1972, repr.: 118-119, see also Regmi, 1971: 20) mentions the manufacture of brass with zinc imported from India and, in his day, not only copper but also brass vessels were exported from Nepal. The composition of Indian brass ("yellow metal") exported to Nepal seems to have a high zinc percentage: 62% copper and 36% zinc (Brown and Dey, 1955: 150). The late Newar brass image analysed by Bhowmik (1964: 395) reflects similar percentages: 60.5% copper and 35.3% zinc. The increased use of brass in 19th and 20th century Newar statuary is witnessed by a number of dated images of deities and devotees with zinc percentage sometimes higher than 40% (nos. 114 and 121 on pp.108 and 109 below), but lower (no. 125) when associated with fire-gilding (see below, p. 83).

Finally mention should be made of the use of brass for the casting of metal reliquary *stūpas* (Tib.: *mchod-rten*) from at least the 13th century (see Hatt, 1980: 210 and 214, *cf.* nos. 29 and 45 on p.104 and 105 below) in Tibet, where brass was commonly used to manufacture all kinds of ceremonial articles from at least the 11th century (see above, p.34 and below, nos. 22, 70, 79).

Tin

Like zinc and lead, tin (Tib.: *gsha'-dkar*) has been imported into Nepal since at least the 18th century (Kirkpatrick, 1975 repr.: 209 and Hodgson, 1972 repr.: 109) and is only used alloyed with copper in Tibetan and Himālayan statuary. The general absence of tin ores from the Himālayas, India and Tibet partially accounts for the rarity of its use in Newar and Tibetan statuary. 'Jam-dpal-rdo-rje (Chandra, 1971: 43) regards "upper, Indian"[18] and "lower, Chinese" tin as the best. His mention of average and poor quality Tibetan tin is not supported by geological evidence. Tin is apparently not even found in eastern Tibet, "for no mention of it is ever made. The white alloy of tin used in Dege for metalwork is imported from China". (Coales, 1919: 246). Although Tibetans did use bronze scrap, it appears that they seldom manufactured bronze for statuary purposes. The analytical data provided by Craddock on pp.26-31 indicate that tin was almost never used in Tibetan statuary alloys, a fact which may be explained by the virtual absence of tin ores from Tibet as opposed to the presence of zinc ores. The low tin percentages to be found in many Tibetan metal images analysed by Craddock only betray the use by Tibetan artists of bronze scraps from bells or other bronze items.

Bronze

Brass and bell metal are both mentioned in Book V of the late 13th century *Rasaratnasamuccaya*, and the latter is described as being made by melting together eight parts of copper and two parts of tin (Ray, 1903: 114). 'Jam-dpal-rdo-rje states that "upper" (Western or Burmese) tin from India was mixed with six or eight parts of copper to produce respectively red and white *li*,[19] the only two types of alloy accurately described in his section on *li* (Chandra, 1971: 41) which may be regarded as bronze (Tib.: *'khar-ba*, *mkhar-ba*, some types of *li*, and perhaps *khro*). However, he mentions those two types of bronze only in connection with the manufacture of certain items, including religious musical instruments, and we know, indeed, that bronze is traditionally used by Tibetans to cast bells (Ronge, 1980: 269-276).[20] The only two types of *li* which 'Jam-dpal-rdo-rje recognizes as being used specifically for statuary purposes are of foreign origin and he does not give us their composition: "as for Chinese *li*, which appears from the smelting of Khotanese ores, there are two: white *li*, of white brilliancy, slightly yellow; and red *li*, of red brilliancy, slightly yellow. The images of the gods are made with them" (Chandra, 1971: 41). Padma-dkar-po (1973, I: 295, 1.1) describes statuary white and red *li* in identical terms and according to him too, both were "obtained in the mountains of Khotan".[21] As for these two types of Chinese statuary *li* obtained from Khotanese ores, it is doubtful what Padma-dkar-po and 'Jam-dpal-rdo-rje had in mind. It is interesting to note, however, that copper occurs in the northern foothills of the Kunlun, between Yarkand and Khotan, and that zinc deposits have been located in the Khotan district, but no tin. Although the manufacture of bronze objects in East Turkestan is demonstrated by Werner's analyses (1972: 190-1),[22] the same author (1972: 141) ventures to say that for the period from the 12th to the 16th centuries the zinc content among the analysed objects from Chinese Turkestan and China "rises sharply to 30% Zn": indeed one standing goddess from Turfan "dated to the 8th century, yielded a zinc content of 27% Zn" (Werner, 1972: 139). These circumstances (see also Marco Polo's information on p.45 and n.7) suggests that brass manufactured from Khotanese ores was exported to Tibet.

It is unlikely that Padma-dkar-po and 'Jam-dpal-rdo-rje had first-hand knowledge of the components of the two *li* statuary metals whose exterior aspect they describe in identical terms, a circumstance which may be due to the fact that both white and red *li* were often of foreign provenance. Since metallographic analysis and careful inspection of Tibetan and Himalayan metal images show that the vast majority are cast either in brass or copper - and the same goes for northern Indian and Kashmiri statuary, whose alloys are again often described by Padma-dkar-po in terms of *li* - it may be concluded that Tibetan writers used the term *li* in the same loose and incorrect manner in which the term "bronze" is used nowadays in the West when referring to objects made of copper or its alloys. It may be further suggested that the terms "white" and "red" *li* used by Tibetan writers in connection with Tibetan and Indian statuary more often than not indicate in fact brass and copper, which are indeed by and large the most common statuary metals used in the area with which we are concerned. The general confusion among Tibetan writers about the term *li* and its composition may be explained by the fact that they were virtually unacquainted with the manufacture of bronze for statuary purposes and were rather out of their depth with the word, which betrays foreign origin. This contrasts with the relative precision of the words they use for copper, gold, silver, lead, tin, zinc, iron and, significantly, brass. This suggestion is strongly supported by the metallographic analysis of an Indo-Tibetan metal image of Pāla-Sena style (p.108, no.105) and inscribed: *De-mo li-ma*, "*li* object of the De-mo"[23] That statuette was cast in brass and no tin is detectable in the alloy. It is described by Béguin (1977: 70) as a northern Indian "replica of an original of the 12th century" and included in a group of Tibetan images betraying very strong Indian stylistic features (Béguin, 1977: 11-12). It shows Umā sitting on Śiva's left leg, with the latter caressing her chin. The donor at the bottom of the pedestal wears a seemingly Tibetan garment and chignon. In connection with the group of Indo-Tibetan images in which Béguin includes this statuette, it is quite interesting to report Padma-dkar-po's verses on statuary in Tibet during the kingdom of *mnga'-bdag* (king) Khri-ral (Ral-pa-can; see above, p. 41). He explains that as for

> The images manufactured by Indian artists (in Tibet),
> Their kind is similar to the images of Magadha,[24] made out of white
> *li* (of the quality called) 'indisputable'.
> As for the dissimilarities setting them at variance,
> Their face is a little plump
> Their *dehanchement* has a great share of grace,
> And the silver and copper openings of their eyes are perfect.
> *Zangs-thang-ma*[25] (images also) occur; they are (with) copper lips
> and silver eyes.

Padma-dkar-po, 1973, I: 301, ll. 3-6.

The description given by Padma-dkar-po in the first four verses above fits remarkably well the group of images studied by Béguin (see above, p.48), which are often inlaid with copper and silver. Is it possible that this kind of statuary was produced by Pāla and Sena artists in Tibet perhaps as early as the 9th century [26] and that the type of white *li* mentioned by Padma-dkar-po was in fact brass? The latter suggestion is confirmed by the metallurgical analysis of the Umāmaheśvara mentioned above, and also by the circumstance that a Tibetan inscription was found inside the base of an 11th-12th century silver inlaid brass Maitreya in Pāla style (Uhlig, 1979: 114-115, fig. 46). Although Neven (1975: 35, no. 67) has implied that white *li* is to be understood as a kind of silver, [27] there would have been little point in inlaying silver statues with silver. All the images belonging to this group are cast in brass and most of them inlaid with silver and copper.

The fact that the term *li* has to be understood in a loose manner as merely indicating any copper alloy is again suggested by the several kinds of uses attributed by 'Jam-dpal-rdo-rje to the various types of *li* which he describes in the same passage (Chandra, 1971: 41). After specifying that white *li*, slightly yellow with white brilliancy, and red *li*, slightly yellow with red brilliancy, are both made from Khotanese ores and used to manufacture metal images (which we know to be cast almost exclusively in copper and brass), he mentions "coloured *li*" (or "coloured *lis*") as the metal used for fashioning the metal circles for *mandals*, [28] although copper is a metal often employed for these. He then states that the "resonant" *li* alloy is used for the manufacture of various musical instruments, such as cymbals, but the term must here indicate "bronze" or "bell metal" (see no. 47 on p. 105). For all these reasons, dictionary translations of the term *li* as "bell metal" or "bronze" and of *li-ma* as "a metalic (*sic*) compound containing more gold and silver with which images are generally made" (Das, 1976 repr.: 1212, from *'Jigs-rten lugs-kyi bstan-bcos*) are either as inadequate or fantastic as the *aṣṭa-dhātu* alloy mentioned above (p. 33).

mKhar-ba (or *'khar-ba*) is another term which has been variously translated as "bronze" and "bell metal". Klong-rdol (1973: 1462, ll. 5-6) explains that:

> apart from black *khro*, [29] (which is) iron, the alloys (known as) 'thousand lotus', like silver, 'poor', like *mkhar-ba*, 'red paradise', like copper, 'clear white', like white iron, are called *mkhar-ba*. lately, all these were made with *dong-rtse* ('copper coins', *cf.* Laufer, 1918: 106). After being perforated in the middle it is easy to carry them. It is reckoned that China and India enjoy (the use of copper coins as) extensive trading currency.

The fact that copper enters into the composition of *mkhar-ba* alloys is confirmed by 'Jam-dpal-rdo-rje (Chandra, 1971: 43), who by the same token gives us a positive definition of it as "bronze": "as for *'khar-ba*, by mixing seven parts of copper to (one of) tin from Khams [30] and (one of) tin from 'Jus (in eastern Tibet; [31] *cf.* Dagyab, 1977, I: 50); it turns into white and red *'khar*, which is used to make mirrors and gongs.". 'Jam-dpal-rdo-rje's proportion of tin to copper corresponds to the mean values of tin percentages found in the Chinese mirrors analysed by Chikashige (1920: 919), or suggested by Craddock (1979:77) in his discussion of *khar-sini* ("Chinese bronze"), an alloy used in Islamic metalwork (see also Allan, 1959: 50ff.). *Khar-sini* may have been a bronze alloy manufactured not only in China, but also in eastern Tibet, perhaps with Chinese or Burmese tin.

Since bell metal varies considerably in composition from about three to five parts of copper to one of tin, and the composition given by 'Jam-dpal-rdo-rje falls within such percentages, we may well accept "bell metal" as a suitable term for translating *'khar-ba*, at least when supported by metallurgical analysis.

In Nepal, according to my Newar informant, the owner of a metalwork atelier at Pātan, tin is present in three types of bronze used in the casting of various domestic and ritual items:

i) Newar "bell metal" with two parts of copper to one of tin, used for example, in the manufacture of water-pots and wine jars;

ii) Newar "bell metal" with three parts of copper to two of tin used, for example, in the manufacture of traditional plates. Neither appellation of "bell metal" by my informant,[32] corresponds to the use of the word in Western metallurgy, where it may indicate any type of bronze in which the parts of copper may vary from three to five, to one of tin (75% to 83% in the alloy);

iii) "bronze", made with two parts of white metal to one of tin, mostly imported from India. The very low percentage of copper from the melt makes it preferable to regard it as a variety of white metal;

iv) white metal, imported from India. In Western metallurgy the term white metal designates three different alloys with high (more than 83%) tin, lead and cadmium percentages respectively.

Images cast in white metal are rare and, because of their weight, I tend to believe that they are made of lead-based alloys, which are cheaper than tin and cadmium alloys. The low melting point of lead and its relative freedom from contraction when solidifying makes it particularly suitable for casting. Alloys i), ii) and iii) have not been mentioned as being used for common statuary purposes by any of my Newar informants. This circumstance confirms my suggestion that the terms "bell metal" and "bronze" as translations of names of Tibetan and Himālayan metal alloys and compounds may be used only in a rather vague and approximate way with regard to ritual and domestic implements and should be used hardly at all in connection with the metal statuary from that part of the world. Buchanan's following remarks also seem to confirm that in the past too the use of bronze by Newar craftsmen was limited to the manufacture of domestic or ritual implements (Buchanan, 1819: 232): "in Lalita Patan and Bhatgang there is a very considerable manufacture of copper, brass, and Phul, which is a kind of bell-metal.[33] The bells of Thibet are superior to those of Nepal; but a great many vessels of Phul are made by the Newars, and exported to Thibet, along with those of brass and copper. Iron vessels and lamps are also manufactured for the same market." (*cf*. Buchanan, 1819: 213).

Silver

The earliest known silver (Tib.: *dngul*) item from Tibet was apparently manufactured in Bactriana and has been studied at some length by Denwood (1973: 121-7). Authentic survivals of silver metalwork from the monarchic period are extremely rare and no serious archaeological or metallographic research has been carried out on the silver jug kept in the Jo-khang at Lhasa and "said to be a recent outer covering, made in replica and containing an original piece dating from the time of *Khri-srong-lde-brtsan* " (lived A.D. 742-797. Snellgrove and Richardson, 1968: 50).[34] It is possible that Iranian silverwork was known in Tibet from a very early period and that its reputation lasted until the 19th century. In fact 'Jam-dpal-rdo-rje mentions that silver, if "roasted in the *ru-ba-da* wood of the country of Khurasan, flowed" (Chandra, 1971: 41), and Das (1976 repr.: 358) maintains that "the kind of silver called *mchog-can* is imported into Tibet from Khorasan". Whereas no silver mining occurs in Khorasan and during the Islamic period silver was used mostly for inlay or for jewellery and coinage, it is a fact that the zenith of the old Iranian silverwork tradition was reached during the Sassanian period (A.D. 224-651) and that Tibet came into contact with

Iranian civilisation by at least the 7th century A.D., and with Khurasan in particular by the beginning of the following century (see al Ya'ḳūbī, 1937: 124). The Tibetan tradition associating silver with the Iranian world is contrasted by 'Jam-dpal-rdo-rje (Chandra, 1971: 41) with the types of silver available in his day, which included Indian *tañkas*, Chinese ingots and Tibetan coins.[15] Klong-rdol (Chandra, 1973: 1461, 1.3) also mentions silver from Hor (Turkestan?) and from Khams. The presence of silver ores in eastern Tibet was first reported by the famous Italian Jesuit Ippolito Desideri (De Filippi, 1937: 121) and by della Penna (1730, in Markham, 1879: 316). In the end of the 18th century silver continued to be worked in eastern Tibet (*cf*. Cooper, 1871: 463) in small quantities at Dar-rtse-mdo (Coales, 1919: 246) and the trend continued in the following centuries. Pranavānanda (1939: 37) mentions that silver is obtained in eastern Tibet and Waddell (1906: 475) specifies that it came from Li-thang and 'Ba-thang. Giorgi (1762: 456) refers to the presence of silver ores in gTsang and Waddell (1906: 475) reports that small quantities of silver were said to be found in the valley west of Se-ra "one day's journey off the Pemba Pass" north of Lhasa. Ronge (1978: 145) mentions the presence of silver ores in lower sPo-bo. However, the output of these deposits was negligible and Tibet continued to import silver from China (Rhodes, 1980: 261; Sperling, 1980: 281; Olson, 1975 repr.: 54; *cf*. Turner, 1800: 381), Mongolia (Bell, 1968 repr.: 122; Rhodes, 1980: 261), and from Siberia (Bogle, in Markham, 1879: 125-6). Chinese silver bullion was available in Dar-rtse-mdo in 1889 (Rockhill, 1891: 208). Tibet imported its silver requirements for minting from China (Rhodes, 1980: 264) and from India (Ronge, 1978: 145). In the 16th century the latter was in turn supplied with large quantities of Mexican silver by the Portuguese, who used to trade it for spices. The great Moghul emperor Akbar (who even had a Tibetan wife in his harem) used surplus silver to trade with Tibet (Rhodes, 1980: 261).

Silver was seldom used to cast images by Tibetan and Newar sculptors (but see no. 30), though its use in statuary does survive even to this day (Alsop and Charlton, 1973: 43).[16] Like copper and brass, silver has been widely employed for *repoussé* work by Newars in Nepal and Tibet and by Tibetans themselves. Three ancient gilded silver images made by a Newar and a Kashmiri sculptor at Kojarnāth, in western Tibet, are mentioned by Tucci (1937: 40 and 1956: 61-2, *cf*. Pranavānanda, 1939: 52 and 161). A good example of a 20th century *repoussé* silver Tibetan statue is the 13 ft. high image of an eleven-headed Avalokiteśvara erected in 1970 in the main chapel of the newly built Tibetan Cathedral in Dharamsala (Dalai Lama, 1970: 14). This image includes faces from the eleven-headed Thugs-rje-chen-po from the Jo-khang in Lhasa, which was destroyed by the Cultural Revolution in 1966. Parts of the heads were somehow rescued by Tibetans and conveyed to India in 1967 and 1968 (Dalai Lama, 1970: 13, and Richardson, 1977: 174).

The use of silver inlay in white *li* and in composite copper and white *li* Tibetan statuary is attested by Padma-dkar-po from the reign of Ral-pa-can (see also above, p.50). Silver has been consistently used for inlay work in brass and copper statuary in Tibet, and the same tradition, traceable to Pāla, Sena and Kashmiri origins, is still followed by leading Newar sculptors such as Nhuche Raj Sakya and Jagat Man Sakya. However, nowadays in the Nepal Valley silver inlay is more often applied to copper than to brass images. Although, according to Abdul Kadir's report of January 6th, 1979, silver mines existed in Nepal and "the natives do not understand working them" (Regmi, 1961: 247), his suggestion is not supported by geological evidence and the yield of silver from lead ores in Nepal must have been negligible. Bhutan imported silver from Tibet and exported it to Bengal (Pemberton, 1961 repr.: 8, 76-7 and 79), but it is likely that the item did not originate from Tibetan ores and was ultimately of Chinese origin.

Gold

Deposits of alluvial gold (Tib.: *gser*) in Nepal are mentioned by Buchanan (1819: 76 and 298, *cf.* Regmi, 1971: 18), but their importance is minor and greatly contrasts with the reputation of Tibet as a gold-bearing country. Della Penna (1730, in Markham, 1879: 316) reports the presence of gold mines in the provinces of dBus, Kong-po (central Tibet), gTsang, Dvags-po (southern Tibet), Byang-thang (northern Tibet) and Khams (eastern Tibet, *cf.* Giorgi, 1762: 456). Saunders (Turner, 1800: 404-5) mentions "large quantities" of gold in the form of gold dust, lumps and veins in Tibet. In 1867 the Indian Pandit Nain Singh explored the gold mines of Thok-ja-lung, in western Tibet, reaching the main gold-field at 16,330 feet, in N. lat. 32° 24'26" and E. long. 81° 37'38", "where the camp of the Tibetan gold diggers was placed. The master of gold diggings was a native of Lhasa, a shrewd and well-informed man. The Pundit describes the method of working of the gold and the habits of the diggers". (Markham, 1879: cxiv and xxiv (see also Trotter, 1877: 102-3). Extensive goldfields in the district of Sankora, western Tibet, were discovered by Swami Pranavānanda, an Indian who made surveys in the 1930s and 1940s in the Mount Kailāśa and Lake Mānasarovar districts. Pranavānanda (1939: 36) mentions the existence of a vein of gold deposits running about a mile south of the Ganga Chu, a discharge stream connecting the Mānasarovar to the Rākṣas Tal. Mining had been abandoned there around 1935, because an outbreak of smallpox "was attributed by the Tibetans to the wrath of the presiding deity of the mines and consequently the mining was stopped by the Government". Besides the goldfields at Thok-ja-lung, Pranavānanda mentions those at Munakthok and Rungmar "some 20 days' march northwards from the shores of the Manas". Those and other extensive and rich deposits were then mined by primitive methods. The mineral specimens collected by Pranavānanda were analysed at Benares Hindu University. Gold mines were also mentioned by Hedin's informants (Hedin, 1922, IV: 99) and gold was used by the 11th century kings of western Tibet not only to gild statues, but also to pay Atiśa for his visit to Tibet in A.D. 1042. In central Tibet, Atiśa was presented by a nun "with the image of a horse made of gold on which a small boy made of turquoise was riding" (Roerich, 1976 repr.: 256).

The gold mines at Thok-ja-lung are again mentioned by Waddell (1906: 474), McGovern (1924: 25), and Tucci (1935: 114-5) and illustrated by a picture of a pit in the Byi'u gSer-ka-kyi Ro area (Tucci, 1937: opp. p. 65) where, by order of the Lhasa Government, it was then forbidden to mine gold, "perhaps because the mines are too close to the border (...). People obey because they are convinced that by extracting from the earth the treasures contained in it, its fecundating power is made barren and its crops impoverished" (Tucci, 1937: 61-2). However, besides the use of common placer techniques, digging occurred in western Tibet: "there are left the traces of the ancient excavation works: deep and narrow pits, like many ant-hills" (Tucci, 1937: 62). Commenting upon Pliny's and other historians' mention of the presence of gold in the area, Petech (1977: 6) states that the "most detailed treatment of the question is still that of Herrmann, who brings arguments to show that the tale" of the "Dards'" gold-digging ants "goes back to a hazy knowledge of gold-washings in Ladakh and Baltistan, and chiefly at Kargyil" (see also Waddell, 1906: 474), Although "gold is found in the sandy banks of the Indus and its tributaries right from Saspolo to Chilas on Dardi Stan" (Francke, 1977: 5) and "was found from the sand of the river Shyok" (Hassnain, 1977: 43), it is more likely that Herodotus's tale is connected with the western Tibetan areas visited by Tucci (1937: 62), than with Ladakh or Baltistan. As for the Dards, Clarke (1977), in Philip Denwood's words, "has relegated them to the status of a ghost people invented by academics."

Gold excavations "in the La-shung country" are mentioned by Hedin (1910, I: 174 and 179), who spotted many trails of gold-diggers in western

Tibet. Most of the Tibetans digging gold in western Tibet came from Shigatse and Lhasa (Hedin, 1910, I: 194) for a period of two or three months and combined their mining activities with the trade of various goods carried during their journeys (Hedin, 1910, I: 171 and 174). On the other hand, in the 19th century, western Tibetans were brought in by the governor of lHa-khang-rdzong, near Bhutan, to dig gold from an old river bed in that area (White, 1971: 201). During the early 18th century Desideri reported that more gold is found in E "than in other parts of Thibet, and in rather larger nuggets." (De Filippi, 1937: 140, see also Karsten, 1980: 163). In parts of central Tibet gold seekers had to buy the rights to prospect for gold (Ronge, 1978: 144; Bailey, 1957: 188; and Karsten, 1980: 165). Gold is found in lower sPo-bo (Ronge, 1978: 145) and Dvags-po (Waddell, 1906: 437 and Bell, 1968 repr.: 110) and Bailey (1957: 188, see also *ibid.* 193) describes the placing techniques used by labourers in the latter district:

> "The way they did it was this. They dug a channel beside the stream about a yard and a half wide. With what they removed they made a dam across the exit of the channel. On this dam they placed five pieces of very short turf about 15 x 8 x 1 inches. These made a weir-top, when the stream was diverted into the channel. Then they dug the mud from the stream-bed up stream and placed it on top of the turf, letting the top get gradually washed away. The mud in this way was removed and the gold dust fell and was caught in the turf. As they worked, they moved slowly down stream, repeating the process over and over again. Twice a day, at noon and in the evening, the sods were removed and the dust washed out of them. The dust went through three stages, being washed first in a wooden pan three feet by one with a hollow in the middle. The contents of the hollow were washed finer in a small wooden bowl and finally these were washed more finely still in a tin. By the second stage I could detect grains of gold. But the deposits were obviously not very rich (....) and (....) if a nugget was ever found, it was replaced because the people believed that the nuggets would breed more dust".

However, gold mines existed in Dvags-po at Mani Serkha and Michung (Waddell, 1906: 437 and map) and the monastery of bSam-yas contained "the State treasure and gold" from those mines (Waddell, 1906: 440, n. 1). South of the gTsang-po river, the nomads of Mus mined gold because they were required to pay their taxes in gold dust (Ekvall, 1968: 55). An episode illustrating the Tibetans' ambiguous attitude towards mining is reported by Macdonald (1932: 220-1): wishing to be self-sufficient in gold supplies, the Tibetan administration sent a monk who had been trained in England as a mining engineer to prospect for gold to the north of Lhasa; however, the reaction of the local monastery towards such irreligious activities was such that, although the prospecting had been successful, the monk was "recalled to Lhasa, and placed on duty as a police officer, with the title of Khenchung, of the fourth rank of monk officials" (see also Thomas, 1951: 130). According to the Nepalese consul in Lhasa in 1904, the best gold came from a reef "a few days' journey due east of Lhasa" (Waddell, 1906: 474).

The presence of gold in eastern Tibet did not escape the notice of Desideri, who first described the placer technique used by Tibetans as observed by him in the early 18th century:

> Gold and silver of good quality exist in the province of Kham, indeed gold is to be found everywhere in Thibet, but there are no mines as in other countries, the people simply separate it from the earth and sand in the following manner. Near the rivers, with great labour, Thibettans move large blocks of stone and dig

> out the earth and sand underneath, which they throw into a trough. Into this, after placing therein large square sods, they pour much water, which running down carried off the earth, the coarser sand and the small stones. The gold and fine sand is caught in the rough grass of the sods, which are washed over and over again until none remains. The gold is generally like sand and not in nuggets. It is usually found in flat land at the foot of mountains, because the rain washes the earth and with it the gold. It is therefore manifest that if the Thibettans knew how to tunnel mines in these sterile, bare mountains they would find much gold.
>
> (De Filippi, 1937: 121-2).

Rockhill (1894: 360-1) left a brief description of an extremely simple method of extraction used in eastern Tibet, as he observed it in 1892. Alluvial gold is widely distributed in the sands of the great eastern Tibetan rivers (Ronge, 1978: 143), where "the usual method of cradle washing is employed, the concentrates being finished off with quicksilver" (Coales, 1919: 246). Similar mining techniques were used in eastern and western Tibet (Ronge, 1978: 144). It is possible that placer mining was favoured because "it can be operated without undue damage to prejudice against digging", which arose from the religious belief that delving into the earth was "to disturb the subterranean demons and destroy the crops and the people" (McGovern, 1924: 343). Centres of gold exploitation in Khams were at some distance from Li-thang (Waddell, 1906: 474), for gold washing was forbidden by the monks in the neighbourhood of the town, although its trade was allowed in Dar-rtse-mdo (Ronge, 1978: 143). Gold dust was traded also at Jyekundo (Rockhill, 1891: 206). An indication of the relative abundance of gold in eastern Tibet is provided by Rockhill (1891: 208), who mentions that the same gold purchased by him in Peking for 20 taels an ounce was worth only 12.5 to 13 taels in Dar-rtse-mdo. He notes that "gold-washing is one of the commonest occupations throughout the country, as every stream seems to contain in its sands particles of the precious metals; and, though the quantity collected by any individual washer is undoubtedly small, the total amount procured annually cannot fail to be of great value." Rockhill (1891: 208-9) was probably one of the first western travellers in Tibet to report that "mining is not allowed in Tibet, as there exists a deep-rooted superstition, carefully fostered by the lamas, that if nuggets of gold are removed from the earth no more gold will be found in the river gravels, the nuggets being the roots of plants whereof the gold dust is the grains of flowers." Taining, a locality north of Dar-rtse-mdo was an active gold-mining centre in 1908 (see Fergusson, 1911: 222) but the goldfields in its neighbourhood had been worked out by 1919 and everywhere "abandoned workings, in the shape of pits in the gravelly soil by the streams" were noticed by Teichman (1922: 61). The most productive gold mines on the frontier in 1918 were in Erkhai, in rGyal-rong and Nyag-rong (Teichman, 1922: 65-6 and 70). Information on gold deposits in eastern Tibet brought "large parties of Chinese" into the country (Fergusson, 1911: 214 and Duncan, 1964: 19), but the Chinese prospectors who appeared in the 1940s could operate only under military authorization and protection (*cf.* Guibaut, 1949: 59 and 174-5).

Gold mines in eastern Tibet are also mentioned by Goré (1923: 324) and Cooper (1871: 474). The eastern Tibetan gold deposits were controlled by natives and could only be exploited by the local rulers, "to whom a small quantity of the gold found in due" (Desideri, in De Filippi, 1937: 122). Although "the yield of gold" was "generally poor", in 1916-17 "several thousands" of Chinese labourers were engaged in exploiting the goldfields 50 miles north-east of Tre-'o, in Hor (Coales, 1919: 246). This gold reached the market of Yunnan (Ronge,1978: 143).

Mining gold by placer techniques is a subsidiary activity of northern and north-eastern Tibetan pastoral nomads (*cf.* Olson, 1975 repr.: 54).[37] However, it "is contrary to nomadic prejudice concerning disturbing the soil and robbing the soil lords. It appears to derive from the proximity of historically worked mines (...) and tax policies which require taxes paid in gold dust (...). A number of pastoral communities prohibit mining altogether and enforce heavy penalties", even death, "for any violation " (Ekvall, 1968: 55). The exploitation of gold in north-eastern Tibet was also made difficult by nomads. Two thousand Chinese Muslims who washed gold in the sands of the Kokonor area had to be protected by soldiers against such incursions (Ronge, 1978: 143-4).

Tibet exported gold from an early time. During the monarchic period (7th-9th centuries A.D.) Tibetan gold found its way to the West *via* the Arab Caliphate (Beckwith, 1980: 35) and to T'ang China, in the form of "bullion or dust" (Beckwith, 1977: 99). Although "gold in dust, grains and small lumps" was produced and exported from Tibet in Kirkpatrick's days (Kirkpatrick, 1975 repr.: 206) and gold was exported from Tibet into Nepal (Turner, 1800: 370 and 372; Buchanan, 1819: 212; and Lévi, 1905, I: 315), Bhutan (Turner, 1800: 383; and Pemberton, 1961 repr.: 76 and 70), China (Turner, 1800: 373 and 381; Bogle, in Markham, 1879: 125; Goré, 1923: 324; and Bell, 1968 repr.: 122), Kashmir, Siberia, and Bengal (Bogle in Markham, 1879: 126 and 128; *cf.* Turner, 1800: 370 and 382), for generations Newar traders exported gold into Tibet, sometimes from India (Ronge, 1978: 145). Thanks to the efficiency of the British mail system, bars of gold packed in wooden crates of the weight of ten pounds could be mailed by one Newar trader from India to Lhasa for minting purposes (Ronge, 1978: 145) early this century. It is likely that the Tibetan administration found it difficult to be self-sufficient in gold as is shown by the episode of the prospecting monk mentioned above. Chinese gold imported from Mongolia (Bell, 1968 repr.: 122) did much to enable Tibet "to keep the balance of her trade" (Kawaguchi, 1909: 456).

Statues cast in solid gold are extremely rare in Tibetan and Himālayan statuary and, as a rule, textual reference to gold images should be interpreted as "gilded". Solid gold has been used to cast or hammer ritual objects and jewellery by Newars and Tibetans, and Landon (1905, II: 309) mentions "rows and rows of great butter-lamps of solid gold" in front of the Jo-bo's altar in the Jo-khang at Lhasa (see also Walsh, 1938: 536 and 538; and 1946: 30), whereas Tucci (1952: 80) mentions solid gold lamps in the chapel of the XIIIth Dalai Lama (A.D. 1876-1934) in the Potala. Gilded silver offerings are mentioned in the same context, thus reminding us that gilding is by no means limited to copper and brass only. Solid gold items in a chapel in the Potala are illustrated by Waddell (1906: opp. p. 400) and Thomas (1951: opp. p. 192). A 20th century golden butter lamp is illustrated and described by Pal (1969: 128 and 160, no. 117). Gold, sometimes solid, was commonly used in jewellery and Gill (1883: 136) was struck by the circumstance that even poor people in Lhasa wore gold jewellery.

The T'ang Annals refer to all kinds of golden presents which the Chinese received from the Tibetans:

> a suit of gold armour, a golden goose seven feet high and holding ten gallons of wine, a miniature city decorated with gold lions, elephants and other animals, a gold wine vase, a gold bowl and agate wine-cup, a gold duck, plate and bowl. Gold animals are also mentioned as decorating the camp of the Tibetan king (*Ral-pa-can*) on the occasion of the visit of a Chinese envoy in 821.
>
> (Snellgrove and Richardson, 1968: 51).

> The king sits in a tent which is decorated with gold ornaments in the form of dragons, tigers and leopards (....). He bears a sword inlaid with gold.
>
> (Snellgrove and Richardson, 1968: 64-5).

Padma-dkar-po (1973, I: 300, 1.3) mentions that gold was used for statuary purposes during the reign of the first "religious" king, Srong-brtsan-sgam-po. It is very difficult to ascertain whether what the Chinese envoys saw in Tibet were gilded rather than golden images. Significantly, Padma-dkar-po (1973, I: 300, 1.6 and 301, 1.6) mentions that gold was used during the first and third period of the religious kings (7th and 9th centuries) for the fire-gilding process (Tib.: *tsha-gser*), which consists in applying a gold amalgam to the metal and driving off the mercury with heat, leaving a coating of gold on the metal surface (see p. 87). Further confirmation of the gilding of metal images during the 9th century is provided by dPa'-bo gTsug-lag-phreng-ba (see Karmay, 1975: 5). By the 9th century it appears that Tibetans had also started to inlay stones in their statuary, since we know from al Ya'ḳūbī that the Tibetan governor of Turkestan presented "a statue made of gold and precious stones" to al Ma-'mun (Petech, as reported by Shakabpa, 1967: 48) during the reign of the Tibetan king Khri-lde-srong-brtsan (*c*. A.D. 800-815). It is likely that the Tibetans derived the idea of inlaying statues with precious stones from the Newars, whose statues were decorated with stones and pearls at the time when the Chinese missions visited the Nepal Valley in the 7th century (see below, p. 80).

Iron

Though thought to be a component of the artificial alloy *zi-khyim*, iron (Tib.: *lcags*, though in other contexts *lcags* merely means "metal" and, *khro-nag*) hardly appears in any significant amount in Tibetan and Himalayan statuary alloys (nos. 44, 66, 82 on pp.105-7).

I understand that the Newar artist Jagat Man Sakya has cast a few images in iron. Alsop and Charlton (1973: 43) confirm the use of iron by sculptors for occasional casting in Pātan. Iron statues are comparatively rare in Tibetan and Himālayan statuary, notwithstanding the presence of ores in Tibet and Nepal (*cf*. Hodgson, 1972 repr.: 109, and Regmi, 1961: 247). Tibet is "full of iron ore" (McGovern, 1924: 343) and della Penna (A.D. 1730, in Markham, 1879: 316; *cf*. Giorgi, 1762: 456) first noticed the presence of "mines of iron" in the country. 'Jam-dpal-rdo-rje dwells extensively on the subject and Klong-rdol (Chandra, 1973: 1461-2) mentions that "the soft Tibetan white iron is a good material for the begging bowls" of monks, into which edibles are thrown by alms-givers; whereas in China "'poor' iron, not tempered, is ideal for various arts and crafts (....). Farming tools are of 'poor' iron from Khams and Kong(-po)". Klong-rdol must have been aware of the fact that, besides its more traditional uses, iron sometimes replaced bronze in Chinese statuary, and that it was used in China not only for temple furniture (braziers, censers, cauldrons and even bells), but also to build pagodas. Though many iron items were imported from China to eastern Tibet (Rockhill, 1894: 340), we know from Rockhill (1891: 207) that "the few pieces of ironware required in Tibet" came from Dar-rtse-mdo and that iron deposits existed at Chab-mdo, in Khams (Rockhill, 1894: 302-4). The existence of iron mines in eastern Tibet is also reported by Cooper (1871: 463-4), Pranavānanda (1939: 37) and Duncan (1964: 19). The existence of iron deposits in Chab-mdo was confirmed by the findings of the geological section of the Chinese Academy of Science (see above, p. 40). Bonvalot (1891, II: 149-151) mentions a forge at Lagong, which was probably supplied by local iron ores (*cf*. Rockhill, 1894: 303-4). Rockhill (1894: 330 and 353) reports the presence of blacksmiths at Nyewa and Li-thang but none of the work he saw was "of a high order, all is very inferior to that of Dérgé". Iron deposits were also located in the Thang-lha Range on the border of Tibet and the province of Tsinghai. Iron mines in the Nag-chu-ka area were reported in production by the late 1950s. Iron is to be found also in western Tibet, where Pranavānanda discovered it on the eastern shores of the lakes Mānasarovar and Rākṣas Tal. It is very likely that Tibet was self-sufficient in iron and the item does not appear in Kirkpatrick's list of exports from India to Nepal and Tibet. Some wrought iron was exported to Tibet from Bhutan (Pemberton, 1961 repr.: 76), where iron was "procured in the hills" during the first half of the 19th century (Pemberton, 1961 repr.: 75). Kirkpatrick (1975 repr.: 176) maintains that "the iron of Nepal is not, perhaps, surpassed by that of any other country" and in A.D. 1795 Abdul Kadir noted that Nepalese worked some of their iron mines (Regmi, 1961: 247). Iron utensils were exported from Nepal to Tibet (Buchanan, 1819: 213 and 232).

Lead

Lead (Tib.: *zha-nye*) is not used on its own for Tibetan and Himālayan statuary, but it is often found in brass and sometimes in copper statues, where it is added to improve the fluidity of the alloy. Lead deposits were located in Tibet by the Chinese Academy of Science after the Chinese occupation of the country (see above, p. 40) and the existence of a lead mine two days' journey from Tashilhunpo is reported by Saunders (Turner, 1800: 405; see above, p. 40) who adds that the ore was "mineralized by sulphur, and the metal obtained by the very simple operation of fusion alone". The lead mines mentioned by Bailey (1957: 167) at Kyimdong Dzong, in Dvags-po, were nearly exhausted at the time of his expedition in 1913. The lead was extracted there "by heating the ore with charcoal". Lead is found in eastern Tibet, between 'Ba-thang and dMar-khams (Cooper, 1871: 463) and in Yu-t'ong (Goré, 1923: 324). 'Jam-dpal-rdo-rje (Chandra, 1971: 43) was aware of the circumstance that lead can be associated with silver ores (*cf.* Saunders in Turner, 1800: 405) and observes that: "it flows out of the place of the ashes (residuum) of silver." He also mentions Indian, Chinese and Nepalese red lead (Chandra, 1971: 61) and explains that: "if you roast it, lead will flow.". We know from Hodgson that there were lead "mines" in Nepal, but there was "no skill to work them profitably" (see also Kadir's report in Regmi, 1961: 247) and the metal was "imported from the plains" (Hodgson, 1972 repr.: 119. *cf. ibid:* 109). Lead, "China red lead" and white lead were imported into Nepal from India (Hodgson, 1972 repr.: 109). According to Jackson (1976: 282) the red lead used by Tibetan painters was imported "as an already powdered pigment from Nepal, India and China".

From the study of Werner's data (Werner, 1972: 184-7, table 4.1) and the analytical data reported by Riederer(Uhlig, 1979: 64-67), it may be seen that lead is present in many Tibetan brass statues, but virtually absent from most copper ones. The same applies to the Tibetan metal images analysed by Craddock (pp.26-31 above). The presence of lead in Tibetan and Himālayan statuary brass dates from at least the 11th century and the Cleveland Buddha (see above, p.34) contains as much as 11% in its brass alloy. It is very likely that western Tibetans learnt of the advantages of adding lead to brass for casting purposes (nos. 42, 63 and 64 on pp.105-6) in amounts even higher than 10%. These varying percentages reflect the inconsistent proportions to be found in Kashmiri statuary: 2.75% lead in the brass Sūrya studied by Lee (1967) containing 78.1% copper and 18.7% zinc (personal communication from Stanislaw Czuma, September 5th, 1970) and 10.37% lead in the brass Buddha illustrated by Uhlig (1979: 122, fig.56) containing 73.106% copper and 13.18% zinc. Newar sculptors only add lead in small amounts when casting brass images (nos. 114, 115 and 121 on pp.108-9). Although the addition of lead reduces the strength of brass, it makes it easier to cast and more suitable for engraving.

Mercury

The importance of mercury in metal statuary is connected with its role in the traditional fire-gilding process (see pp.80-83)

Mercury (Tib.: *dngul-chu*) enjoys a great reputation in Indian and Tibetan medical and alchemical literature and occupies the first place in the list of precious substances which can be melted, as examined by 'Jam-dpal-rdo-rje (Chandra, 1971: 40), thus preceding gold, silver and copper. 'Jam-dpal-rdo-rje (Chandra, 1971: 40, 1.3) quotes the "Phyi-rgyud", the fourth book in the medical *tantras*, the *rGyud-gzhi*, to say that mercury "is manufactured by roasting cinnabar". He further distinguishes vermilion (*mtshal*) from cinnabar (*cog-la-ma*) and again mentions that if one roasts the former "quicksilver flows" (Chandra, 1971: ll. 2-3). As to the latter, "it is called *mtshal-rgod* ('wild vermilion') and also *rgya-mtshal* on account of its appearing in India (Tib.: *rGya-gar*) and China (Tib.: *rGya-nag*). In the native red stone there is a great deal of purple. It is like an arrangement of wide needles. By melting it there appears mercury" (Chandra, 1971: 59, ll. 1-3). The Tibetan *rGya* is an adjectival prefix which may indicate India or China. Chinese vermilion was occasionally exported to Europe during the first half of the eighteenth century and its reputation for high quality became firmly established from the second half of that century (Harley, 1970: 116). Vermilion, a synthetic mercury sulphide, was probably imported into Tibet "from India or China, both of which had the technology for synthesizing it since ancient times" (Jackson, 1976: 277). There is evidence that both "singraf or vermillion (*sic*) cinnabar" and mercury were exported from India to Nepal and Tibet (Kirkpatrick, 1975 repr.: 209 and Hodgson, 1972 repr.: 109) during the 18th and 19th centuries and it seems unlikely that either country had the technology to manufacture vermilion before then. Cinnabar, the native mercury sulphide, "occurs naturally in some parts of South-East Tibet. It is easily recognizable by its reddish metallic appearance and extremely heavy weight" (Jackson, 1976: 277). However, vermilion made by the sublimation method is pretty well indistinguishable from the best native ores (personal communication from Mavis Bimson). Native Tibetan cinnabar ores "exported to the low country for sale" are mentioned by Turner (1800: 78 and 296) and "cinnabar, containing a large portion of quicksilver" by Saunders (Turner, 1800: 405) who travelled through southern Tibet to Tashilhunpo. Saunders, who was a surgeon, only mentions mercury in connection with its preparation for medical uses (Turner, 1800: 410–11). Mercury ores are found in lower sPo-bo (Ronge, 1978: 145) and according to a Tibetan informant (Berglie, 1980: 41 and 40) cinnabar is found at Mount Targo, in central Tibet, and in a place near Mount Kailāsa. Tibetans knew how to extract mercury from the cinnabar deposits near 'Ba-thang and used it specifically for fire-gilding purposes (Ronge, 1978: 145). The earliest reference to cinnabar ores in Khams (eastern Tibet) is to be found in della Penna (A.D. 1730, in Markham, 1879: 317, *cf.* Giorgi, 1762: 456). Also Cooper (1871: 463-4) and Pranavānanda (1939: 37) mention the existence of mercury ores in eastern Tibet. However, both quicksilver and cinnabar appear in Turner's list of Chinese exports to Tibet. Turner (1800: 372) maintains that Tibetans did not know how to extract mercury from cinnabar, though he mentions the existence of mines of cinnabar, containing a great proportion of mercury and used "for colouring, in paint". In the same work, however, Saunders (Turner, 1800: 410–11) observes:

> Nor could I allow myself to think that they were acquainted with the method of preparing quicksilver, so as to render it a safe and efficacious medicine. In this, however, I was mistaken (...). There is one preparation of mercury in common use with them, and made after the following manner. A portion of alum, nitre, vermilion, and quicksilver, are placed at the bottom of an earthen pot, with a smaller one inverted, put over the materials, and well luted to the bottom of the larger pot. Over the small one, and within the large one the fuel is placed and the fire continued for about forty minutes. A certain quantity of fuel, carefully weighed out, is what regulates

them with respect to the degree of heat, as they cannot see the materials during the operation. When the vessel is cool, the small inverted pot is taken off, and the materials are collected for use. I attended the whole of the process, and afterwards examined the materials. The quicksilver had been acted on, by the other ingredients, deprived of its metallic form, and rendered a safe and efficacious remedy.

This passage, along with 'Jam-dpal-rdo-rje's observation, suggests that Tibetans were aware of the property of heated mercury and cinnabar to evaporate and knew techniques of collecting mercury during the heating process.

According to Nadkarni (1954, II: 72), cinnabar was also "found in Nepal", and Buchanan (1819: 264 and 272) confirms the existence of cinnabar mines in Nepal. Such mines were "worked to some extent" (Regmi, 1971: 18). However, as we know from Buchanan (1819: 212; see also Imperial Gazetteer of India, 1908: 121) that Chinese quicksilver found its way to Nepal and as cinnabar appears in Kirkpatrick and Hodgson's lists of Indian exports to the country, it is very unlikely that Nepal was self-sufficient in mercury in the 18th and 19th century. The metal was much needed in the fire-gilding technique commonly used in Newar metal statuary. It is possible that the Newars were also acquainted with the technology necessary to synthesize mercury and that vermilion was manufactured in both Kathmandu and Pātan (*cf.* Regmi, 1971: 23 and 67). However, it is not clear whether Regmi, who mentions the castes manufacturing "vermilion", distinguishes between red lead and vermilion, when using the latter term: the Nepalese word *sindur* translates both "vermilion" and "red lead". It may be noted here that all the mercury and cinnabar exported from India to Nepal and Tibet was not of Indian origin, since there is no evidence for the existence of either in India (Brown and Dey, 1955: 299).

Notes

1. The brass statuettes described by Uhlig (1979) as "western Tibetan" often include a floating scarf, the shape of which conjures up the outline of a *stūpa* dome. However, this characteristic, as well as their general stylistic features, is not to be found in any statue or statuette, whether Kashmiri, Ladakhi or actually western Tibetan, to be seen in the shrines illustrated in relevant books by Tucci (1935, III), Snellgrove and Skorupski (1977 and 1980) and Govinda (1979, II: 153-181 and 183). Because the above mentioned scarf motif is conspicuous by its absence from all western Tibetan images, whether made of clay or of metal, to be found *in situ* and because of stylistic differences, there is in fact no evidence to support the description of that group of brass statuettes as "western Tibetan", of which I have never come across one single example during my visits to various monasteries in Ladakh. Thus the attribution by Uhlig (1979) of a large number of brass images to western Tibet should be treated with caution. An interesting technical feature of this group of images is that they often have a very thin cast (*cf.* Howes, 1980: 95).

2. On the location and mining from ancient times of copper ores in northern India, see Brown and Dey (1955: 146-154): "there are many occurrences of copper ores in the outer ranges of the Himalayas at intervals from Sikkim in the east to Kashmir in the west. In Sikkim they were worked extensively in the past by Nepalese miners". A copper mine in Kamraz (Kashmir) is mentioned in Kalhana's *Rājataraṅginī* (Book IV, vv. 616, in Stein, 1900, I: 176). Ray (1956: 210) states that "mining of copper ores and the extraction of the metal had been carried out on a large scale in the various states of Rajputana

(Rajasthan) from a very early time till towards the end of the 19th century". On copper ores from the Darjeeling area see Piddington (1854: 447-9).

3. Again, the land of the Kirātas (western Himālaya) is mentioned in connection with the production of copper pyrites in Book II, v. 77. The same verse occurs in Nāgārjuna's *Rasaratnākara*, vv. 25-30 (*cf.* Ray, 1956: 130 and 168). Nepal is mentioned as a copper-bearing country also in the *Dhātukriyā* (couplets 143-5 in Ray, 1956: 210). The earliest mention of Nepalese copper in Chinese literature is probably that by Hiuen Tsiang, who travelled to India from A.D. 629 to 645 and reports that Nepal "produces red copper (...). In commerce they use coins made of red copper" (Beal, 1884, II: 80, *cf.* Watters, 1905, II: 83). Since Hiuen Tsiang obtained his information in India, it appears that by the 7th century India already looked on Nepal as a copper-bearing country.

4. Buchanan, 1819: 76-7, 203, 242, 264, 267, 269, 272, 275, 297 and 301. In Parbat (or Malebum) alone "the mines of copper are said to be twenty-five in number and produce a great revenue." (*ibid.*: 272).

5. See, for example, the "Customs House Returns, Yatung" and the mention of metal imports in Chandler (1905: 65). *Cf.* Chandra, 1971: *passim*.

6. For the term *andànico*, see Olivieri, ed., *Il Milione*, Bari (1912: 28 and 34). The same word appears also in C. Steiner, ed., Cecco Angiolieri, *Il Canzoniere*, Torino, 1928, comp. no. 105, v. 2. Cecco Angiolieri (1260-1311/13) uses the term in connection with the word "steel" and Marco Polo with the words "iron" and "steel". From Marco Polo's description of the process, I should think that the translation of *andànico* as "zinc carbonate" or "zinc ore" would be more appropriate than the current Italian dictionary definitions of it as "very hard metal, akin to iron and steel", for I do not regard the leading Italian comic poet of the Middle Ages as an authority in mineralogy. On the same process, see the reference given by Craddock (1979: 69). *Cf.* also Forbes (1964, VIII: 265ff). Zinc oxide has a pigmentary strength somewhat superior to white lead, and having the added advantage of being non-poisonous, is used in cosmetics. Marco Polo says that "excellent collyrium" was made from the tutty by the inhabitants of Kobiam. However, Ponchiroli (1979: 299) translates *andânico* as "antimony" (*ferrum indianicum*, "Indian iron"). Antimony is highly toxic to the human body and irritates it both internally and externally.

7. Amongst the objects from east Turkestan analysed by Werner, there is one from Ko-cho (Turfan oasis) with 31% zinc (Werner, 1972: 190-1, no. 24). If its dating is correct, it would seem that the manufacture of metallic zinc in that area began in the 13th/14th century, since a zinc percentage in excess of 28 is evidence of the use of the complicated method to extract zinc from its ore by means of an external condenser.

8. *Cf.* Forbes (1971, VIII: 281): "Though the value of the old Indian alchemists and their modern commentators is very doubtful it seems that zinc was prepared by Indian chemists since the twelfth century, but that this remained a laboratory experiment and was never applied to industrial production. This zinc or 'the essence of tin' as it is sometimes called was prepared by distilling calamine with organic substances in an apparatus suitable for *destillatio per descensum*, where a substance could be heated in an upper flask and the drippings could be collected in a lower one."

9. *Cf.* Ray (1956: 122). Ray (1909: lvii) uses a copy of the *ms.* preserved in the Runbir Library, Kashmir, of which the "readings are on the whole accurate" (*ib.* footnote). A fuller discussion of the use of metallic zinc in medieval India is contained in vol. I, pp. 156ff., where Ray concludes: "In the medical Lexicon ascribed to king Madanapala and written about the year 1374 A.D., zinc is (...) distinctly recognised as a metal under the designation of *Jasada*". The extraction of zinc is also mentioned in the 12th century *Rasārṇava* which is believed to be a Tantric work of the 12th century A.D. (Ray, 1956: 119). Section VII, vv. 37-8, states that calamine mixed with various ingredients and "roasted in a covered crucible yields an essence of the appearance of tin" (Ray, 1956: 138).

10. Also: *cung-zho*. This word has been inadequately translated as "a kind of white stone" (Jäschke, 1972 repr.: 141), "a medicinal white stone alleged to cure diarrhoea" (Das, 1976: 383), and "calcite" (Hübotter. 1957: 125). 'Jam-dpal-rdo-rje (Chandra, 1971: 46) lists five types of *cong-zhi*, with colours varying from that of rock-salt, to white, bright purple, yellow and even blue and black, and says that the first two are found in hot springs. It may be suggested that the word indicates a range of minerals from sodium carbonate to calcium carbonate (calcite, calcareous spar).

11. Sphalerite, a sulphide of zinc, is the chief ore of that metal. The colour varies widely. Generally, it is a shade of reddish-brown to black, but some sphalerite is green, yellow or, in crystals of high purity, almost colourless transparent to translucent. Calamine is usually coloured green, blue, yellow, grey or brown by impurities (*cf.* Forbes, 1964: 261).

12. In view of the above considerations (p.37) on red *li* and of the composition of northern Indian alloys, I suggest that Padma-dkar-po is here equating white *li* with brass.

13. *Cf.* Tucci (1959: 187). Dagyab (1977, I: 55) suggests that such statues were probably used in the public 'ceremonial' acts of worship *(sku-rim)* offered by the Yung-lo emperor (1403-1424). *Cf.* also Karmay (1975: 95-6).

14. Padma-dkar-po (1973, I: 295, 1.2) explains that "those images which are made with white *li* for the body and red *li* for the garment are called *zangs-thang-ma*" see also Tucci (1959: 181, n. 6) and Dagyab) 1977, I: 52 and 57).

15. It is possible that during the early monarchic period Tibet imported brass from Iran. Close connections between Tibet and Iran at that time are confirmed by a number of historical sources.

16. See also Dagyab (1977, I: 56-7). Gilded brass images are increasingly encountered in Sino-Tibetan statuary from the 15th century onwards (see above, p.35).

17. This kind of Sa-skya-pa portraiture may have reached its climax before the rise of the dGe-lugs-pa power in Tibet, at a time when the Sa-skya-pa enjoyed the patronage of the Mongols, and continued during the reign of the Yung-lo emperor, only to diminish from the triumph of the Yellow Hats in the 17th century. Describing the "new Chinese" statues, Padma-dkar-po specifies that "the two corollas (Tib.: *kha-sbyar*) of the lotus divide one above the other and adhere at the front and back" of the base (1973, I: 304, 1.4). Karmay (1975: 95) notices that "in many

respects, Padma-dkar-po's account, although describing Ming bronzes in general, concords with her description of the Yung-lo bronzes in particular.

18. "Upper" and "lower", as used by Tibetans in a geographical context, mean respectively "upstream" and "downstream" and here, as is often the case, they stand for "West" and "East" of the gTsang-po river, namely Western Asia and China respectively. Although no one would question the presence of important tin deposits in China, the picture is quite different for India, a country which has traditionally imported tin ores, at least since the 3rd-2nd centuries B.C.: "The oxide of tin cassiterite, has been found at a number of places in the Hazaribagh, Ranchi and Gaya districts of Bihar, but none of the occurrences appear to possess economic importance, though as long ago as 1849 tin ore was being smelted in village iron furnaces at Purgo, in the Palganj estate near Parasnath" (Brown and Dey, 1955: 167). "Outside Bihar, cassiterite has been found, but again only in insignificant amounts (...) There are no recorded instances of the occurrence of tin ore in Pakistan" (Brown and Dey, 1955: 168). Discussing the use of metals at Taxila, Marshall (1951, II: 563) acknowledges that "even if these deposits were worked in ancient days (which is uncertain), they would not have been adequate to meet the needs of the country.". Marshall infers that tin was then imported from the West, to which may be added Finch's observation (1599), as reported by Brown and Dey (1955: 168), that Burmese tin served all India. A detailed study of the history of Indian statuary metals is outside the scope of the present paper and I am satisfied with bringing circumstantial evidence to my suggestion that bronze was not the obvious alloy to use for statuary purposes in India, owing to its lack of tin ores. Significantly, Marshall (1951, II: 566) states that the Sanskrit *kastira* derives from the Greek word for tin, *kassiteros*, and "not vice versa". Indeed, we understand from Pliny that the coastal districts of western and southern India "possessed neither bronze (*aes*) nor lead, but exchanged precious stones and pearls for them." (Marshall, 1951, II: 564-566). Ray (1956: 57) confirms that, "silver, tin and mercury ores (...) are till now not known to occur in India". The "upper Indian" tin mentioned by 'Jam-dpal-rdo-rje may have been Western or Burmese. As I cannot find any trace of Burma being regarded as a separate geographical entity in Tibetan literature, I assume that Tibetans may have assimilated Burma to India. Since in the 19th century the British felt justified in regarding Burma as a province of the Indian Empire, it is difficult to expect that Tibetans would have been more sensitive to the subtleties of geographical distinctions in the Indian subcontinent. Similarly, Arab writers did not regard Lower Burma as a separate geographical entity from Bengal (Gopal, 1965: 51-2). The suggestion that Burmese or western tin was exported to Tibet via north-western India and western Tibet may answer 'Jam-dpal-rdo-rje's apparent contradiction of "upper, Indian" tin.

19. It has been suggested that white *li* is "an alloy of silven and bronze" (*cf.* Neven, 1975: 35, no. 67), although such a statement has not been supported by metallurgical evidence and is challenged by its accurate definition as given here by 'Jam-dpal-rdo-rje. Padma-dkar-po's recurrent use of the term for various periods and schools of statuary and the rarity of images cast in any kind of "white" metal point to the suggestion that white *li* must have been some other kind of alloy. On the evidence provided by the results of the analyses discussed above, Craddock suggests that white *li* is a high zinc brass (above, p.24), although the zinc percentage could not be higher than 30 in Padma-dkar-po's day. However, 'Jam-dpal-rdo-rje's definition, coupled with Klong-

rdol's statement that both red and white *li* as well as yellow *li*, iridescent *li*, and dark reddish-brown *li* are used to make musical instruments suggests that in this particular instance those names of alloys actually indicate bronze (see the analyses of nos. 47 and 80 and Craddock above p.24). On iridescent *li*, see above, p.43. Neither the yellow nor the reddish-brown varieties of *li* are mentioned by Klong-rdol in connection with statuary purposes (Chandra, 1973: 1462, ll. 2-3).

20. See note above. Cymbals "and other musical instruments" were also exported to Tibet from China (Turner, 1800: 381). Hor was the best source of bronze products and in Amdo Tibetans would receive bronze items from Peking and Dolonor (Ronge, 1978: 146-7). On the metal workshops of Peking see Montell (1954); on those in Dolonor see Huc (1924, I: 80) and also Rockhill (1891: 131).

21. Tib.: "Li-yul". This name is sometimes also used to designate Nepal. The Tibetan *yul* means "country".

22. It may be mentioned here tnat in upper Hor (East Turkestan) a mixture of white and red (*li*?) was used to manufacture "dark *khro-li*" (Padma-dkar-po, 1973, I: 302, ll. 1-2), a term not to be found in 'Jam-dpal-rdo-rje's *Materia Medica*, but for which the word "bronze" might be suggested if only the bronze objects from that area analysed by Werner did not belong mainly to one bracket of three centuries (7th-9th centuries) and come mostly from one site (*cf*. Werner, 1972: 190-2). On *khro* see below. On *khro-li* see Dagyab, 1977, I: 52, no. 7.

23. A brass Green Tārā studied by me at Messrs. Spink of London in 1979 and a brass White Tārā studied by me at Sotheby's in 1980 bear identical inscriptions. Karmay (1975: 30) mentions a standing Vajrasattva bearing the same inscription in a private collection in London. I have never come across the description of a "*de-mo*" type of *li-ma* in any of the Tibetan texts dealing with the subject and I am rather inclined to follow the suggestion that the inscription was the owner's mark. From Ferrari, we know that *De-mo* (Qutuqtu) was the name of three important regents of Tibet: "the first incarnate, an important figure in the history of Tibet, was regent for the VIIth Dalai-lama from 1757 to 1777; the second was regent for the IXth and Xth Dalai-Lama from 1810 to 1819; and the third was regent for the XIIIth Dalai-lama from 1886 till he was in 1895 deposed and thrown into prison by the young Dalai-Lama, who took the government in his own hands.". Their residence was bsTan-rgyas-gling, the most important monastery in Lhasa, in the northern part of the city. In 1912 the monastery was destroyed by the Tibetan government because it had taken sides with the Chinese. Afterwards, the Post Office of Lhasa was installed on its premises. We know that at the time of H. Richardson's mandate in Tibet the *De-mo* lived in the gZhi-sde College in Lhasa. bsTan-rgyas-gling was apparently built by the regent of Tibet, which means later than 1642 (Ferrari, 1958: 93). It is possible that due to the vicissitudes of the *De-mo* and their seat, their collection of metal images started being scattered even before the Chinese occupation of Tibet in 1959.

24. In this connection it may be interesting to note that according to dPa'-bo gTsug-lag-phreng-ba, who completed his *History* in A.D. 1565, all statues in the temple of 'U-shang-rdo, erected by Ral-pa-can south of Lhasa, "were modelled on the gods of Magadha in India, cast in white and red *li* and gilt with gold from the river Dzam-pu" (Karmay, 1975: 5 and 7). Direct connections between Tibet and Bengal started at the latest in the mid-8th century, when the Pāla kings had to pay tributes

to king Khri-srong-lde-brtsan in A.D. 755-6 (see Stein, 1962: 39 and 43).

25. For a different type of *zangs-thang-ma*, see above, n. 14.

26. It may be suggested, as Béguin does, that these images are replicas of more ancient Pāla and Sena statues. A few of these statues, however, may have been made by Indian artists working in Tibet (see p.34). Others were produced by Newar and Tibetan artists working from Indian models. Indian statuary styles were in fashion in Tibet for centuries as illustrated by the fact that the Tibetan scholar Tāranātha (b. A.D. 1575) commissioned Newar sculptors to make a statue of Jambhala "in the Indian style" (Tucci, 1949, I: 278). Tibetan images in Indian style are difficult to date because they were produced at various times. The ability of Newar sculptors to imitate alien schools is witnessed by the occasional appearance of 20th century artifically aged copper and brass statues on the international antiques market. What appears to me to be a copy of no. 119 on p.109, for example, was sold as an "antique" in London eight years ago.

27. Elsewhere, Neven (1975: 12) describes *li-dkar* as "a rarely encountered alloy, characterised by a whitish tinge (*dkar*), differing from silver in its lack of oxidation". The term is of very frequent occurrence in Tibetan literature describing Tibetan and Indian statuary alloys which, however, are seldom made of silver or bronze. See also note 19.

28. These items are described and illustrated by Dagyab (1977, I: 34 and II: 17, Fig. 19).

29. *Cf.* Das (1976 repr.: 175): "The kind of bronze called *khro-nag* or dark bronze is also called *lcags khro* on account of the predominance of iron in the compound." The analyses reported above (pp.26-31) exclude the likelihood of such an alloy being used for statuary purposes. Das never mentions tin but rather speaks of zinc - to justify his translation of *mkhar-ba* as "bronze". In fact, Klong-rdol seems to take great care to exclude *khro* from the various types of *mkhar-ba* (bronze) he mentions. If we had to follow Das's own explanations, we should suggest translating the term as "brass" rather than any kind of bronze, at least as far as *khro-dkar* is concerned (*cf.* Dagyab, 1977, I: 50). 'Jam-dpal-rdo-rje (Chandra, 1973: 44) qualifies *khro-nag* as "iron" and mentions that the Chinese one is used to make ploughshares and roasting pans (those used for parching barley), thus confirming that we are in the presence of an iron compound, not quite of "bronze". Farming tools are specifically said by Klong-rdol (Chandra, 1973: 1461-2) to be made of iron from Khams and Kong-po. It is likely that, as in the case of *zi-khyim*, which is absent from 'Jam-dpal-rdo-rje's compilation - and probably of non-Tibetan origin too - Tibetans imported *khro-nag* and did not know its constituents, or that its manufacture was limited to eastern Tibet (Dagyab, 1977, I: 50). Even Das (1976 repr.: 175) acknowledges that the alloy "is largely manufactured in China". Dagyab's definition of *khro-nag* as "an alloy of iron and '*khar-ba*" (1977, I: 50) does not cast much light on the issue, for he fails to define '*khar-ba* with any certainty and, generally, to provide any kind of metallurgical evidence in his study of Tibetan statuary metals.

30. On the white tin alloy used by sDe-dge metalworkers, see above, p.49.

31. It is possible that this eastern "Tibetan" tin came from ores near the

border with Burma. A region with the name of 'Dzud is placed precisely in proximity of the Tibeto-Burmese border in Wylie's map of Tibet according to the *'Dzam-gling-rgyas-bshad* (Wylie, 1962: opp. p.286). However, it is more likely that this eastern Tibetan tin was in fact imported from China and Burma (see above, n. 18).

32. My informant, Jagat Man Sakya, uses an English word either found in dictionaries or heard from foreigners. His proportions should be taken very cautiously until they are substantiated by metallographic analyses of actual samples of the objects he mentions.

33. *Cf.* Klong-rdol's text on "the manner to recognize precious substances": "there appear various counterfeit types of *li* in Nepal, Khams and Tibet, soundless and of a black colour." (Chandra, 1973: 1462, 1.3).

34. The "pottery drinking vessel, said to have been used by *Srong-brtsan-sgam-po* and now enclosed in silver" as mentioned by Snellgrove and Richardson (1968: 50-1), appears to correspond to Srong-btrsan-sgam-po's bowl described by Tucci (1952: 77) as being encased in a silver vessel on which he could read a date corresponding to A.D. 1946. However, Richardson (1977: 181) maintains that the "round-bellied silver jar with a long neck surmounted by a horse's head" bears a date corresponding to 1946, "a new covering in exact replica having been put over the original jar for its protection" and mentions Srong-brtsan-sgam-po's "earthenware beaker, now protected by a silver case", without giving a date for the latter.
A silver portrait of Khri-srong-lde-brtsan is mentioned by dPa'-bo gTsug-lag-phreng-ba (Karmay, 1975: 4 and 31, n. 28). From Chinese sources we also know that in A.D. 824 Tibet presented China with a yak, sheep and a deer "all cast in silver" (Demiéville, 1952: 203, footnote): "Gold and silver objects are often mentioned among the presents offered by Tibet to the Chinese court.".

35. Klong-rdol (Chandra, 1973: 1461, 1.3) seems to have a high opinion of Chinese silver, but not to extend it to Indian silver: "the 'Indian yellow' one is the faulty one from India and Nepal". It is true that Newars sometimes use a poor type of silver, with a yellow tinge, to cast jewellery items. As a rule, however, Newars use almost pure silver for their jewellery.

36. In the shrine of Mr. Ravi Raj Karnikar, the keeper of the main teashop in the Darbar Square of Pātan, there are two splendid cast silver images of a six-armed Bhairava and of an eight-armed Mahālakṣmī standing on two lions. Unfortunately they are displayed for public veneration only once a year, on Yunyapuni. As I missed the opportunity of studying them on September 16, 1978, because of the compact crowd of visitors, I could not examine their inscriptions and can only provisionally assign them to the early 20th century. They both measure 22 cm x 15 cm.

37. Nain Singh gives the location of a few goldfields between N. lat. 31° and 33° and E. long. 84° and 88° and describes their organization and methods of extraction (Trotter, 1877: 102-5 and map). These fields were not as rich as the western Tibetan ones and their exploitation was not very lucrative.

OUR THREE MAJOR ART PUBLICATIONS

1 RGYAN DRUG MCHOG GNYIS (Six ornaments and Two Excellents) reproduces ancient scrolls (1670 A.C.) depicting Buddha, Nagarjuna, Aryadeva, Asanga Vasubandhu, Dignaga, Dharmakirti, Gunaprabha and Sakyaprabha. Reproductions are as per originals today after 300 years of display and worship with an attempt at restoration or retouching. The exposition in English presents the iconographical niceties and the theme of the paintings, namely, the Mahayana philosophy; the treatment is designed to meet the needs of the general reader with an interest in the Trans-Himalayan art or Mahayana. A glossary in Sanskrit-Tibetan a key to place names and a note on source material are appended. Illustrated with five colour plates and thirteen monochromes. (English text) Folio 54 Second Reprint. 1980 and priced at Rs. 150/—

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3 TALES THE THANKAS TELL: Subtitled An Introduction to Tibetan Scroll Portraits. The book has 64 pages (11 and half inches and 8 inches) and contains well produced eleven colour plates, with Jacket depicting Buddha Sakyamuni and his two disciples. The book tells much about Mahayana Pantheon and particularly about the legends and myths around Buddhism as depicted through numerous Scroll Portrait forms. These colourful portraits speak about the contacts with the traditions of Tartary, China, India, Iran and Byzantium. Pub. 1989 and priced at Rs. 200/—

CASTING OF DEVOTIONAL IMAGES IN THE HIMĀLAYAS: HISTORY, TRADITION AND MODERN TECHNIQUES

E Lo Bue

Both solid- and hollow-casting by the lost wax process have a long history in Northern India. According to Reeves (1962:29), the earliest literary evidence for the process is the description contained in the *Madhūcchiṣṭavidhāna*, as recorded in chapter 68 of the *Mānasāra*, which is believed to have been compiled in the Gupta period (Shukla, 1958, II:108). Unfortunately, surviving cast metal statuary from this period is rare, and Bhattacharya (1979:62) suggests that the extensive use of metal for sculpture in northern India may not be earlier than the late Gupta period. From the early medieval period (7th to 12th century AD), more texts are found containing references to metal casting techniques. Of particular importance is the *Viṣṇudharmottarapurāṇa* (III:43-4), which mentions both hollow- and solid-casting by the *cire-perdue* method (Reeves 1962:32). This text is well-known in Nepal (Pal, 1970:13; Lévi, 1905, III:133). However, the best medieval description which gives detailed instructions is contained in the *Abhilāṣitārtha-cintāmaṇi* (a text also known as *Mānasollāsa* or *Mānasollāsa-śāstra*) which was written in c. AD 1131 by king Someśvara Bhūlokamalla of the late Cālukya dynasty of the Deccan (Saraswati, 1936:139; Reeves, 1962:32; Ruelius, 1974:2.1.2). The verses on the lost-wax process, as translated by Saraswati (1936:143), also specify that the ratio of brass and copper to wax should be 10:1 (or, according to a variant reading, 8:1). By this time, hollow-casting had reached a degree of perfection which enabled sculptors to attempt very large images, for which the repoussé technique is otherwise generally preferred. The 2.225 m. high Sultanganj copper Buddha (in Birmingham City Museum) was cast in more than one piece by the hollow-casting method and it is very likely that the 1.86 m. high Devsar brass backplate (in Srinagar Museum, Kashmir) was cast by the same method.

The History of Buddhism in India, written in AD 1608 by the Tibetan scholar Tāranātha (b.1575) states that during Devapāla's rule (c. AD 821-861) the work of two outstanding Bengali painters and sculptors, father and son named Dhīmān and Biṭpalo respectively, gave rise to new schools of painting and metal statuary (Chattopadhyaya, 1970:348). Reeves (1962:23) suggests that the resultant "widespread use of the *cire-perdue* process was to influence the manufacture of copper icons in Nepal and Tibet at the turn of the 10th century AD, particularly with respect to copper gilt images which are still produced there today". As in the past (Khandalavala, 1950:22), both solid and hollow lost-wax casting methods are still used by Newar sculptors, the former for medium size (15 cm to 45 cm) to large (from 45 cm) images, the latter for small (15 cm or below) and sometimes medium size images. The use of the two methods overlaps for medium size images ranging from 30 to 45 cm. There is no evidence to support Dagyab's claim that in Tibet permanent moulds for solid-casting were more widely used than the method of lost-wax casting (Dagyab, 1977, I:50). Ronge (1980:269) also appears to overlook the use of the lost-wax process in Tibetan statuary: "in Tibet bells as well as statues were made by the sand-casting method which requires the mould to be destroyed after casting". However, Pal (1969:29) accepts that the "bronzes in Tibet were usually cast by the *cire-perdue* method". A careful visual examination by Craddock (personal communication) of the 121 objects of flash lines, failed to show any evidence especially on the underside of the bases.
It seems probable that both techniques of casting were used in Tibet. The earliest evidence for the introduction of the lost-wax process into Tibet is probably provided by a western Tibetan Vajrapāṇi at the Musée Guimet in Paris (MA.3546). This statue was hollow cast in brass (11.7% zinc and 1% lead) by the lost-wax process, as is shown by radiography which

revealed the presence of a core held together by a metal armature (Hours, 1980:95-98). This image, attributed by Pal (1969:22, Figure 6) to the 11th-12th century and regarded by Béguin (1977:89) as a copy of an 11th century Kashmiri "original", appears to provide the earliest evidence for the introduction of the lost-wax process into western Tibet.

The continuous presence of Newar sculptors in Tibet is attested in Tibetan and Western sources from the 7th (Norbu and Turnbull, 1972:143; Dagyab, 1977, I:36) to the 20th century (Huc, 1924, II:244; Bista, 1978:196 and 202-3). The career of Aniko, a Newar artist who was sent to Tibet at the head of a team of eighty artists in AD 1260 (Lévi, 1905, III:187; Petech, 1958:59; but see Tucci and others who give the figure twenty-four, probably mistranslating Lévi's French "quatre-vingts") is only one example. Aniko was subsequently invited to the Mongol court in China, where he was put in charge of the imperial metal-works, and received posthumous honours. Beeswax and copper are listed by the *Yuandai huasu ji* (see below, p.82) amongst the materials used by Aniko (Karmay, 1975:23). For every subsequent century, the presence of Newar sculptors is documented in various parts of Tibet. Newar communities existed at Lhasa, Shigatse, Gyantse, Sa-skya and Tsetang. Although the figure of 20,000 Nepalese residents in Tibet (Nepali, 1965:25) is certainly exaggerated, what matters rather than their numbers are their social and anthropological features. They all belonged to the three Newar castes among which metal sculptors are still to be found: Vajrācārya, Śākya and Uda. During the early 17th century in particular, their activities extended from Guge (Pereira, 1926:96-7; see Lévi, 1905, I:79-80) to Bhutan (Ardussi, 1977:245-6), which is still supplied by the Newar metal sculptors of Pātan. The number of Nepalese metal images in Tibetan temples was legion and Newar sculptors have also been active producing statues in Tibetan style (Lo Bue, 1978 and 1981). There is, however, no historical evidence that Tibetan metal sculptors ever worked in Nepal. Furthermore, the current absence of local lost-wax statuary manufacture from Bhutan, Ladakh, and the Tibetan areas of Nepal, including the Tibetan refugee settlements where there are quite a few outstanding painters, suggests that Tibetan lost-wax metal statuary depended heavily upon Newar sculptors well into the 20th century (Lo Bue, 1978 and 1981). For these reasons, and in the absence of living Tibetan lost-wax metal sculptors to act as informants, I have thought it acceptable to base the following sections on fieldwork which I carried out in 1977 and 1978 among Newar sculptors working for Tibetans in Nepal.

A pioneering study by M-L de Labriffe (Mrs Anthony Aris) on lost-wax metal casting in the workshop of Jagat Man Sakya in Oku Bahal, Pātan, was published in *Kailash* in 1973. Another study by Alsop and Charlton was published in *Contributions to Nepalese Studies* later the same year. The following sections are intended to sum up the knowledge of the contemporary technique of Newar lost-wax casting and aim chiefly at supplementing these earlier studies with more detailed information, especially with regard to the timing of investing and casting.

Wax model

The composition of the wax used in modelling varies according to season in the Nepal Valley. The light "summer" wax is made with a mixture of 50% beeswax, bought from Tamangs living in the hills surrounding the Nepal Valley, and 50% *sila*, a tree resin imported from India. Reeves (1962:30) restating, perhaps with the aid of a Tamil translation, the defective (Saraswati, 1936: 140; Krishnan, 1976:7-8) Sanskrit text of the 68th chapter of the *Mānasāra*, defines the dammar used to manufacture statuary wax as the resinous sap of the *sāl* tree. Now the *sāl*, or *Shorea robusta*, abounds in the sub-Himalayan regions, including the Nepalese Terai. The dark "winter" wax is made with a mixture of one *dhārnī* (= 216 *tolās*. One *tolā* = 11.663 gm. Regmi, 1961:21) of beeswax, 1.5 to 2 *pāos* (27 to 36 *tōlās*) of *sila* and about 0.5 *pāo* (9 *tōlās*) of vegetable ghee extracted from the seeds of the tree *Madhuca butyracea* (Roxb.) Macbride (*sive Bassia butyracea* Roxb.; Nep. *cyurī*), a Sapotacea attaining 21 m. in height which is distributed in the sub-Himalayan tract from 300 to 1500 m. altitude and grows also in the Kathmandu district (Suwal, 1970: 52). We thus have the proportion 24:3 (or 4):1 for beeswax:resin:vegetable oil. Krishnan (1976:30) mentions mustard seed oil instead of vegetable ghee and gives the following proportions: sixteen parts of beeswax, eight parts of resin and one part of oil. To manufacture the modelling wax, small pieces of beeswax are first melted in a brass or aluminium pan over a low flame on a charcoal brazier and then the powdered resin is added and stirred well. Finally, the vegetable fat is added and stirred vigorously.

The round wax sheets (Plate 1) used by sculptors for modelling their images are prepared by beating a cake of wax with a mallet and by spreading it uniformly on a stone slab with a roller. The thickness of the wax used varies according to the size of the statue to be cast and the type of metal to be used. Hollow copper images require a thicker wax model than brass ones. The chief tool used in wax-modelling is the *silatu*, a buffalo-horn spatula rounded at both ends, one end being wider than the other, and with one side slightly rounded and the other almost flat, so that its edges are not sharp (Plate 2c). Labriffe gives the spelling *silāyakū*. The outline of this spatula is reminiscent of the shape of a fountain pen. *Silatus* vary slightly in size, but they usually measure between 14 cm and 18 cm in length and are about 5 mm thick. A larger type of *silatu*, keeping the shape of the horn from which it is made, but cut at both ends (Plate 2a), is used to roll wax rods, which are employed to make attributes, necklaces, etc. The importance of the smaller *silatu* in modelling the wax is such that Kalu Kuma, one of the leading sculptors in Pātan who specialises in the manufacture of tantric deities in Tibetan style, regards it as a sixth "finger". Other tools, such as the scissors (Plate 2e) used to cut wax, are made of metal or wood.

The sculptor models the parts of his image, whether hollow or solid, without a core, by skilful manipulation of portions of wax sheet and use of the *silatu* (which is frequently moistened with saliva to avoid sticking) near a portable charcoal stove (Plate 1), (*ou cha*; Labriffe, 1973: caption opp. p. 187 has *milācā*) made of clay called *ghoti cha* (Labriffe, 1973:189, n.13c has *gathi*), and provided with a door to admit the draught in the lower section and a perforated fuel receptacle in the upper. The stove used by Kalu Kuma measures 18 cm in height and has an external diameter of 28 cm. The various sections of a wax figure or of its component parts are joined by evening out and heating their edges before attaching them (Plate 3). Once the wax model is completed, the artist wets the surface with water and presses on pieces of slightly heated thicker wax in order to obtain the *thāsā* ("key") (Plate 4) or "female" sections of a mould which will allow him to duplicate the same image, or parts of it, in future. The *thāsā* also ensures that in case of mis-casting the time employed to remodel the image will be reduced. In order to model from a *thāsā* the sculptor or his apprentices wet the insides of the sections and press the slightly heated thinner sheets of modelling wax against them. The various sections obtained from the *thāsā* are then jointed together following the original model to form a complete figure or parts of it. The method of casting images in several parts with separate attributes which are subsequently joined together is a traditional feature of Tibetan and Himālayan sculpture (see below, p.78, and Khandalavala, 1950:22).

Although apprentices may be involved in all modelling operations connected with the *thāsā*, the modelling of the prototype is carried out by the sculptor alone. Finally, ornaments, jewellery and attributes to be cast with the figure are modelled and fitted to the assembled wax figure. Kalu Kuma makes use of a black stone obtained from Tibet, carved in low relief with the "female" moulds of a number of religious attributes and ornaments which are part of the accoutrements of his tantric deities. Once a wax model or its parts are complete, a wax tripod is fitted to their bottom edge; its rods will become sprues when the wax is melted away.

During the whole process, the artist makes use of a basin filled with water to cool and harden the wax as necessary, and of a small pot filled with molten wax for retouching and joining. It should be noted that he does not use cores at any stage of the modelling, although a core is automatically formed when investing the wax of hollow models.

Investing the wax

The investment of the wax is carried out by the sculptor or an apprentice, or by a specially hired clay worker, as was the case with the investing of a number of small and medium size wax images which I observed in one of Kalu Kuma's workshops in the summer of 1978. The investment of Kalu Kuma's models by this artisan was carried out during four days of sunshine. This account follows a chronological sequence to give an idea of the time involved in the various operations.

5 September 1978

A paste made of fine clay (Nep. *mashinō mātō*; New. *mashin cha*), water and cow dung in equal proportions is applied to all the less accessible parts of the model. Immediately afterwards, a more liquid, creamy solution of the same composition is splashed and poured over and, where appropriate, inside the wax model or its parts (Plate 5). To improve access to the interior of a hollow model a small window may be cut in the wax and the paste pushed through to form a core. The window may be replaced before smearing the outer surface with subsequent layers, or may be filled with clay and only closed with a piece of copper sheet after casting is complete. The excess creamy solution is then shaken off and the clay left to dry in the workshop for about twenty-four hours.

6 September 1978

A thick paste made of yellow clay (Nep. *pahenlō mātō*; New. *masu cha*), water and rice husks is applied on top of the first layer. The resulting moulds are then put on a roof terrace to dry in the sun for a couple of days. Clay and rice husks are kept separately and mixed with water in a large clay pot as required.

8 September 1978

One or more iron nails are driven through the outer layers into the wax and the inner layers of clay to act as chaplets, so that during the melting of the wax the core of hollow models will not be displaced and thus hinder the molten metal from reaching all parts of the mould. A thicker layer of thick clay paste is subsequently patted onto the moulds, which are finally left to dry completely (Plate 6).

Removing the Wax

Dewaxing and the subsequent operations will be described here in a time-sequence referring to the casting in copper of the images whose investment has been described above. They took place in the small courtyard (320 cm x 210 cm) and porch of Kalu Kuma's old house, on the evening of 13 September, 1978. The evening was chosen because casting is obviously more bearable in cooler conditions. Kalu's son, Rajesh, directed the operations, which involved four other workers, including his own brother-in-law, two other assistants of Kalu, and one of another sculptor's apprentices.

Although some workshops are provided with a dewaxing stove (Plate 7) and firing kiln (Plate 8) besides the furnace for melting the metal (Plate 9), the Kumas use a dual-purpose yellow clay kiln measuring 68 cm x 48 cm x 56 cm and built on a similar principle to the stove described above (p.72). Here, however, the lower compartment has a larger door for admitting the draught, and the top compartment is a chamber built with a temporary front wall of loose bricks. The kiln is not moveable, being built against one of the walls of the courtyard.

5.00 p.m. The moulds are placed on a charcoal fire resting on the receptacle separating the lower from the upper compartment of the kiln. They are turned with tongs until thoroughly heated, but not baked, for a period varying from 2 to 5 minutes according to the size of the mould. They are then removed, the head of the tripod is pierced and the wax flows out through the sprues into an earthenware bowl. It takes a few minutes for all the wax to escape, and eventually the sprues are cleared with metal tools in order to ensure a passage for the molten metal to be poured in later. The wax will be re-used for modelling, after replacement of its vegetable ghee.

5.15 p.m. Copper sheets and scraps (including wire and a variety of bits and pieces) are hammered to the smallest possible size and jammed into an open glazed ceramic crucible 20 cm high and 16 cm in external diameter. These crucibles are imported from India and are used especially for casting copper.

Firing the mould and melting the copper

5.40 p.m. The fire in the kiln is reactivated with paper, dry corn-cobs and small bits of wood,and then the draught from an electric fan is directed into the door. Charcoal is added and once it is burning well the fan is switched off.

5.45 p.m. Coal is placed in the hearth of a furnace built like the stove and the kiln from bricks and yellow clay, and located in the corner opposite the kiln. Its measurements are 79 cm x 79 cm x 66 cm. Coal is not found in Nepal (Imperial Gazetteer of India, 1908:119) and is now imported from India, but it does not appear to have been imported in the past. As a fuel it has probably replaced charcoal for casting, whereas wood is still used for firing moulds (Alsop and Charlton, 1973:38). In Tibet, coal was available in the eastern part of the country (Cooper, 1871:463; Saunders, in Turner, 1800:406; Duncan, 1964:19). Combustion is aided by directing an electric blower into a pipe protruding 15 cm from an opening in the lower compartment of the furnace. The blower is luted to the pipe with clay.

5.50 p.m. Cross-armed crucible tongs are brought into the courtyard (Plate 10). Their length varies from 117 cm to 142 cm and their fulcrum is located so as to allow maximum grip when holding the crucible. Their ends are semi-circular so as to fit almost all the way round the crucible. Glowing coal is transferred from the furnace to the kiln in order to reach a higher firing temperature.

5.55 p.m. The coal in the furnace is burning with a flame 60 cm high, undoubtedly because of the draught from the electric blower.

6.00 p.m. The crucible containing the metal is placed directly on the coal in the furnace and a brick chamber is built around it. The chamber is one brick thick and leaves the upper portion of the crucible visible. Pieces of copper stick out of the crucible to a length of 15 cm. The crucible is not fixed in position, but rests on the coals which are continually topped up.

6.10 p.m. A convex iron lid is placed over the furnace chamber. Charcoal is added to the receptacle of the kiln and moulds are placed on it for firing. They will have to be brought to a temperature close enough to the melting point of copper (1083°C) to prevent the metal from starting to solidify before the mould is completely filled, and the mould itself from cracking

during pouring. No thermometer or other form of temperature control or measurement is used by Newar sculptors even today.
6.12 p.m. Blue flames 15 cm long spit horizontally from beneath the furnace lid.
6.17 p.m. The lid is red hot and four sheets of scrap copper hammered to equal size are put around it, leaning partly on the temporary brickwork of the chamber. More copper scraps, mostly sprues recovered from previous castings, are beaten, and coal is hammered into fragments.
6.20 p.m. The kiln receptacle is filled with coal and a slate is put as a roof over its three walls, while a temporary wall of bricks and clay is raised in front of it to seal off the moulds in a chamber. The scrap copper sheets which were being heated on the top of the furnace are hammered while hot to a size to fit the crucible.
6.28 p.m. The furnace lid is so red as to appear almost transparent. A large ceramic bowl, measuring 18 cm in height and 51 cm in diameter, is filled with water in preparation for cooling the moulds after casting.
6.35 p.m. The position of the crucible is adjusted with a long iron bar through an opening in the temporary chamber wall, and the lid lifted. The copper in the bottom of the crucible must have started melting because the level of the red hot copper scraps visible above the rim has dropped. They are further pressed down with an iron bar. Small copper scraps are poured into the crucible from a ladle, 9 cm in diameter and 27 cm long, provided with a wooden handle.
6.37 p.m. The crucible is red hot and more coal is added to the chamber by hand. Both coal and scrap copper are carried in metal buckets.
6.45 p.m. The furnace lid is lifted to add more scrap copper to the crucible. After removing part of the temporary front wall, Rajesh puts five more moulds into the kiln chamber and adds charcoal.
6.50 p.m. The bricks are put back and the flames in the kiln chamber are fanned with a piece of straw matting.
7.10 p.m. The furnace lid is lifted again to add more bits of scrap copper.
7.20 p.m. More charcoal is added to the kiln chamber.
7.35 p.m. The coal level in the furnace chamber is topped up. The kiln is fanned again.
7.40 p.m. A wall two bricks high is built on the ground in the porch to support the fired moulds during casting.
7.45 p.m. The temporary front brick wall of the kiln chamber is dismantled and the fired clay moulds are placed on the ground, leaning against the two-layer brick wall. They are red hot and stand upside down with the opening (i.e. the head of the tripod) pointing upwards, ready to receive the molten metal.
7.50 p.m. The copper is molten and casting begins. Rajesh stirs the molten copper with an iron bar to check that melting is complete before pouring it into the opening of the mould. A certain amount of spilling occurs, probably because the open glazed crucibles are difficult to handle. No precaution is taken to ensure that the air escapes from the moulds. Consequently mis-castings are not rare, as I saw the following day, when the tripod-shaped sprues were sawn off the bottom of the copper statues and parts of statues.

The above time-table shows that it took one hour and fifty minutes for the copper in the crucible to melt and one hour and thirty-five minutes for the clay moulds to be fired. The copper castings are allowed "to cool and harden for about fifteen to thirty minutes. The cooling is speeded by pouring cold water over the mould, which emits huge amounts of steam. Finally the entire mould is placed in a large jug of water to complete the cooling process" (Alsop and Charlton, 1973:39).

The casting operations for copper were not very different from those for casting brass, as I had observed them in the house of the sculptor Sanu Kaji Sakya on 12 September, 1978. Preparations started there at 4 p.m. Both his kiln (71 cm x 71 cm x 120 cm) and his furnace (94 cm x 91 cm x 132 cm) are located in the porch adjacent to the courtyard. Sanu Kaji's furnace is larger than Kalu Kuma's and has a 14 cm x 14 cm window to admit the draught located 25 cm from the floor. The sculptor and his assistants were casting medium size images of Vajrapāṇi, Amitāyus and a Burmese style Śākyamuni. Lotus bases, bodies and head-dresses were cast separately. The crucibles were oval and 24 cm high with a short spout near the bottom. They were completely sealed to prevent loss of zinc from the alloy. These crucibles are made by the artists themselves and, according to Krishnan (1976:31), withstand only one melting operation. After the crucibles had been sufficiently heated for the brass to melt, they were removed from the furnace and their spouts perforated with an iron rod. Brass melts at a lower temperature than copper and appears more fluid and easier to cast; the molten alloy was poured into the moulds without the spilling noticed in Rajesh's workshop.

After casting, Sanu Kaji dropped each hot clay mould into a brass basin full of water, with considerable steaming and bubbling. The moulds remained in the water for a few minutes and were then taken out to be broken with an iron bar (Plate 11). The fired clay came off the metal statues easily and, as is to be expected with brass, Sanu Kaji's casting had a higher rate of success than Rajesh's in copper.

Cleaning up and assembling the cast

After removing the clay from the casts, the sprues are sawn off and the statues are then cleaned and polished for hours with the help of files (Plate 12), sandpaper and rags. None of the operations described above has to be performed by the artist, although most sculptors do their own casting.

Finally the statues are assembled, mostly by means of crimping and riveting although in the past split pins were also occasionally used. The backs of the neck, shoulders and wing attachments of Kalu Kuma's 44 cm high copper Garuḍa, made in c. 1971, provide a good example of crimping combined with riveting and dovetailing; the head is held in place by fitting it between the shoulders and driving a rivet between the shoulder-blades into the neck. The neck ornaments conceal the junction and the continuation of the neck into the shoulders so that the rivet is hardly noticeable. A crack in the dovetail joining the right wing and shoulder-blade of the Aniko Collection Garuḍa (Inv. no. 119; on loan to the Victoria and Albert Museum) reveals that the wing is also provided with a tenon inserted into a corresponding hole in the shoulder-blade (Plate 13). The latter type of fitting is always used to join medium or large size figures to their base or vehicle. The bottom of the figures and their backplates are provided with tenons which fit into corresponding sockets in the base or vehicle (Plate 14 a-c).

The casting of an image in several parts has the advantage of reducing to a minimum wastage due to mis-casting, besides allowing the sculptor to model wax surfaces which, being smaller, are relatively easy to handle. Newar and Tibetan sculptors adopted this technique from an early date, as may be seen from a c. 13th century gilded copper image of Maitreya, cast in four pieces by the lost-wax process and regarded by von Schroeder as an example of the Sino-Newar school of Aniko (Uhlig, 1979:168-9, no.95). Separate casting is favoured for both medium size and large images, but is also frequently used to cast components such as the base, backplate and attributes of smaller statues, sometimes in different alloys or metals, according to circumstances and taste. Although specialists in Tibetan and Himalayan art tend to be suspicious of figures where analysis has revealed a different composition from that of the base, backplate or halo, it should be noted that such differences are not necessarily evidence of forgery or restoration work. Bases and backplates may be cast, or even hammered, several weeks after the figure to which they belong, for a number of reasons, such as division of labour, availability of metal, delays due to weather conditions, time of year (Newar metalworkers are extremely reluctant to work during the numerous festivals of the Newar calendar), and mis-casting. Because of the use of scrap in the alloy, it is not surprising that brass castings of different parts of an image made only a few days apart in the same workshop may give significantly different results in the composition of the alloy. Furthermore, availability of metal and taste may also account for the use of different alloys for different parts of the same image, as is the case for a c. 17th century Tibetan copper image of Na-ro-mkha'-spyod -ma dancing on a brass base (British Museum: 1905.5-19.11; p.105, no.38) and for an 18th-19th century Ṣaḍakṣari (Werner, 1972: Figure 31). The same applies to other pieces, like a Tibetan copper statue of Sitatārā sitting on a brass base (British Museum: 1880:126; p.103, no. 4), the 15th century 25 cm high Tibetan statue of Padmasambhava illustrated in Christie's catalogue of their sale on 19 February, 1980 (p. 19, no. 79), and various other pieces. Although the possibility of later restoration work cannot be excluded as an explanation of the use of different metals in the same image, it is important to stress the role played by chance and taste in composite metal statuary from Tibet and the Himālayas. The same observations apply to original restoration work, where different metallurgical data from the same statue only prove that time has elapsed between the first and second casting, but cannot quantify it, whether in terms of days or centuries, unless other evidence is available.

With the polishing of the casting, the task of the sculptor is completed; for chasing, engraving and inlaying are carried out by the chaser, who also seals the underside of the statue with a sheet of hammered copper after the consecration of the image,and may inlay semi-precious stones where necessary. Although the first two operations are decisive for the final appearance of a metal image, the techniques and tools of the chaser (Dagyab, 1977, II:51-2, pls. 67-69 and 71) are rather different from those of the sculptor, and chasing, engraving and inlaying, as well as statuary embossing, deserve separate treatment. Suffice it to say that the chaser gently beats the surface of the casting with the aid of a little hammer and punch,before engraving it with a hammer and chisel. Copper is soft and relatively easy to chase and engrave, whereas brass is hard and brittle and few chasers challenge that medium with more than an average performance, though such was the case for a brass Tārā (Victoria and Albert Museum, I.S.21-1980; no. 121 on p.109 below). Copper is also more suitable for mercury-gilding than brass, particularly the leaded brass commonly used by Newar metalworkers (see p. 59). The materials used for inlay work in copper are usually silver and gold, but copper is used for inlaying brass. Gilding is seldom associated with inlay work, although I have seen one example of gold and silver inlay in a partially gilded copper statue of Dīpaṅkara. This combination of techniques finds an antecedent in at least one example of a post-Gupta gilded metal image, whose eyes are inlaid with silver (Majumdar, 1926:425). According to Khandalavala (1950: 24-25) "the practice in Nepal of setting ornaments and crowns of images with semi-precious stones was .... derived from late Pala art .... . The practice of gilding Nepalese copper images is also borrowed from Pala metal sculpture where gilded images are frequently met with". Even earlier, however, "stones and pearls" are reported to have decorated statues in the four pavilions of a building in the ancient capital of the Nepal Valley at the time of the missions of Wang Hiuen-ts'e in AD 647/8 and 657 (Lévi, 1905, I:157 and 159 and II:164-5). Tibetans traditionally prefer turquoise and coral for inlaying their metal images.

Gilding

Fire-gilding or mercury-gilding, that is gilding by means of a mixture of mercury and gold, is mentioned by Padma-dkar-po as being used in Tibet from the 7th century (see p. 58). However, textual references are scanty and the technique is not described in detail by any of the Tibetan sources used for this introductory study. Ray (1956:115) refers to a text of the *Kubjikā Tantra* "in the valuable manuscript collections of the Maharaja of Nepal. This was written in Gupta character and copied about the 6th century AD. In this Tantra we find allusions to the transmutation of copper into gold with the aid of mercury". It is possible that mention of such a transmutation in Indian and Tibetan alchemical literature is merely descriptive of fire-gilding. Mercury is referred to in connection with copper in the *Rasāyanaśāstroddhṛti*, a text which was translated and included in the Tenjur, and is therefore earlier than AD 1335. The translation by Suniti Kumar Pathak (Ray, 1956: 469) of the Tibetan version of verses 17 and 18 concerning copper and mercury interprets it as hinting at fire-gilding on copper, but is, to say the least, excessively free. The word for "gold" does not appear once in the corresponding Tibetan verses. On p. 30 of the *Yuandai huasu ji*, a record of the materials used by artists of the Mongol court between AD 1295 and 1330 at a time when Aniko was active there, mention is made of an image being "adorned with Tibetan liquid gilding" (Karmay, 1975:23), which is perhaps a reference to mercury-gilding. In the Nepal Valley, mercury-gilding has been used from the 10th century (see p.88) and Newar artists have always preferred this gilding technique on metal statuary almost to the exclusion of any other, even after 1979 when electro-plating was first introduced. The Newars probably derived that gilding technique from India, although few examples of gilded northern Indian statuary have survived. Majumdar (1926:427) assumes that the 84 cm tall standing Mañjuśrī from the ancient city at Mahasthan (Bogra District, Bangladesh) was mercury-gilded. However, he contradicts himself in regarding the image first as "not earlier than the Pala period" (Majumdar, 1926:425), then ascribing it to the Gupta period (ibid.:426-7). S K Saraswati, who knew the piece well, calls it "of definitely Gupta workmanship" and "gold-plated" (Saraswati, 1962:26), by which he seems to have understood fire-gilding. He describes its "fine plating, thinner even than an egg shell" and, in explanation, briefly quotes an account of contemporary Newar fire-gilding (Saraswati, 1962:30). Antiquities found at Mahasthan indicate that the city continued to flourish after the Gupta period and, since very few surviving metal images can be unquestionably given a Gupta date, it may be safer to assign the statue to the post-Gupta period. This view finds support in Dani (1959) and Asher (1980:94).

Although the method of fire-gilding became very popular in the Nepal Valley for the gilding of cast or repoussé Buddhist and Hindu copper images (Pal, 1974:33), there is no evidence that all copper statues from Nepal were gilded or were meant to be gilded. Parcel-gilding appears in Newar statuary from at least the 17th century, perhaps less for aesthetic reasons than as an economy measure, as the back of the image often remained ungilded (Khandalavala, 1950:22) and was painted red. This kind of parcel-gilding became very common in Nepal in subsequent centuries. The front of the statues, with the exception of the hair, was always entirely gilded and polished. Sometimes the main figure was gilded and its accessories left ungilded. Waldschmidt (1969: no. 39) and Werner (1972:211, Figure 31) illustrate an 18th-19th century Newar gilded image of Ṣaḍakṣarī seated on an ungilded throne with an ungilded ornamental back and canopy. This statue and all its parts were cast in brass (Werner, 1972:184-5, no. 173 a-c). Examples of mercury-gilded brass from an early period are less common, but brass was being used in Newar statuary from the 10th-11th century Since 1959, parcel-gilding for aesthetic purposes has occasionally been carried out on copper statues meant for the Western and Tibetan markets. This was also a common feature in eastern Tibetan and Sino-Tibetan brass statuary from at least the 18th century onwards. Usually the jewellery and naked parts of a figure, with the exception of the hair, were gilded, and the garments, or parts of them, were left ungilded, or vice versa. This applied to both the front and back of the statue. Parcel-gilding has also been used on repoussé metal work from at least the 18th century and is still very common, particularly on domestic and ritual objects meant for Tibetan customers.

Newar artists are aware nowadays of the difficulty of fire-gilding brass and of the impossibility of fire-gilding leaded brass (pp.92-4), but it is uncertain how far they were acquainted with the problem from an early period. Tibetans probably learnt from them, as is suggested by a fire-gilded brass Śākyamuni dated to c. 1500 (Uhlig, 1979:180 and 183, no. 107). The alloy of that image contains only 0.16% lead and 8.40% zinc, the percentage of these two elements probably having been kept low in order to avoid any adverse behaviour of the alloy when exposed to heat during the fire-gilding process.

Cold gilding is mentioned by Padma-dkar-po as being used to gild the statues of Tibetan kings during a period corresponding to the 8th century (Padma-dkar-po, 1973, I:301,1.3). Cold gilding may be done by the application of gold leaf to the surface of the statue, either by burnishing it on, or by using an adhesive. It seems, however, that the most common technique for cold gilding statues is painting. Traditionally, gold paint is prepared by binding ready-made lentil-shaped drops of gold dust with glue. The exact method of preparation of these drops is still a secret known only to the Newars, and in Tibet only a few Newar goldsmiths residing in Lhasa possessed the technique, the names of their establishments being "well known to the painters of Central Tibet" (Jackson, 1976:232). However, one way of making finely powdered gold is by cutting sheets of gold leaf into small ribbon-like strips, mixing them with powdered stone and glass and grinding them with a little water (Dagyab, 1977,I:45).

Cold gilding is particularly suitable for statues made of materials other than metal, and the 14th century clay groups of Srong-brtsan-sgam-po and his two wives preserved in the Potala (Snellgrove and Richardson, 1968: 154; Stein, 1962:247 and pl. opp. p. 246) and the Jo-khang (Sís and Vaniš: [1957] 133 and 147-9 are certainly gilded by that technique. Gold paint is still used by Tibetan and Newar artists to give the faces and necks of Tibetan images their characteristically matt golden colour. This practice is very common in Tibetan metal statuary, whether fire-gilded or not, and in the former case the gold paint is applied over the mercury-gilded surface of the face.

Finally, mention should be made of the use of gold as an offering in the alloy of statuary metals, as is revealed by Himalayan copper and brass images with a gold percentage higher than about 0.01%, although Werner suggests a lower limit of 0.05% (Werner, 1972:146-7, table 9.6, nos. 167, 173 and 208) The 25 cm high brass statuette of Ṣaḍakṣarī (Werner, 1972:184-5 no. 173 a-c; see above p. 82) has a gold content of 0.13%, although it is not clear whether the result of the analysis may have been biased by the fact that the main image is actually gilt, because its backplate and base have only 0.012% and 0.008% of gold in the alloy. However, the detection of pieces of gold leaf beneath the surface of a few *thang-kas* (Bruce-Gardner, 1975) by means of an infra-red viewer, suggests that gold may have been similarly added to statuary metals for purely religious reasons. It is possible that this circumstance contributed to the creation of the myth of the "octo-alloy" (see above, p. 33).

The surfaces of ungilded copper images made nowadays by Newar sculptors are often finished by smearing them with mustard seed oil or even shoe polish in order to give them a patina. The aim of this is not necessarily to make them look antique. The tradition of waxing metal images is very ancient in Tibet and may be due to aesthetic reasons or to the realization that it was a good method of preventing oxidation. The fire-gilded images made at the time of king Srong-brtsan-sgam-po were smeared with *byo rtsi* (for "*byo rtse*") (Padma-dkar-po, 1973, I:300, 1.6) a term translated by Tucci (1959:185) as "resin or greasy material". Similarly, the statues made during the reign of Khri-srong-lde-brtsan "were smeared with *byo rtsi*" (Padma-dkar-po, 1973, I: 301,1.2)and Chinese statues made during the Ming dynasty "were actually smeared with *zho rtsi*" (Padma-dkar-po, 1973, I:304,1.5). This literally means "curds varnish", although Tucci (1959:186-7) translates the corresponding expression from his anonymous manuscript as "red".

Antiquing

The antiquing of images in the Nepal Valley started in the nineteen-sixties as a result of the growing demand for Tibetan and Himalayan antiques in the Western art market, and it is now carried out by a few specialists in Pātan and Kathmandu. The artificial ageing of works of art is forbidden in Nepal and this makes it very difficult for the researcher to get in touch with professional forgers who, in any case, are not ready to disclose their trade secrets. Some artists, like Kalu Kuma, mark their images in order to avoid trouble with the Department of Archaeology of Nepal, which issues the permits and seals necessary for the legal export of all works of art, the export of items over one hundred years old being now forbidden. However, that does not prevent some Newar and Western dealers from having artificially aged a large number of the statues bought from modern artists. Various methods of antiquing have evolved during the last two decades. In the nineteen-sixties, dealers were generally happy with darkening brass images by heating them at a high temperature, thus obtaining a black patina on the metal surface. Labriffe (1973:192) mentions heating over oil lamps, but it is doubtful whether such a method was ever popular, for the soot would come off the metal surface easily and stain the hands of any potential customer, thus defeating its purpose. I understand, however, that a similar method was used to age paintings. Occasionally oxidation is induced by smearing the statue with acids and Labriffe (1973:192) says that some statues were smeared with a mixture of lemon and salt and kept in a damp place surrounded by cloth for a period varying from six to twelve months. She also mentions another method, consisting of smearing the statue with liquid manure, ashes, salt and cow-dung and burying it in the ground for a year, in order to obtain a corroded surface. However, such relatively primitive methods of oxidation are now seldom used, perhaps because collectors have realized that ancient Newar and Tibetan metal images are never excavated from archaeological sites, but come from temples and shrines where they are reasonably well protected and corrosion is minimal. A green patina on any Himalayan statue is almost certainly the result of forgery (Pal, 1974:32-33).

During my visits to the Nepal Valley in the nineteen-seventies, I made several cautious attempts to get in touch with professional forgers, but only managed to create suspicion and fear amongst my informants. Although antiquing methods vary, they can be reduced to two basic techniques: rubbing and heating with a chemical agent. Rubbing is carried out for many days with cloth which may be imbued with any kind of greasy material, including milk, and incense. The heating of mercury-gilded images smeared with sal-ammoniac (ammonium chloride, which was, according to Buchanan Hamilton (1819:212) an item imported from China to Nepal in the 18th century) partially destroys the gilding, but gives the effect of mild corrosion which successfully dupes many buyers of Tibetan and Himalayan antiques. Finally vermilion and other ritual substances may be smeared on the forehead or other sacred parts of the statue to add the final touch of "authenticity" to the image, as if it had just been snatched from the altar. In some cases forgeries are left incomplete to simulate loss due to age. The most sophisticated methods of antiquing are used for statues which are especially commissioned from sculptors by Western dealers, on the understanding that no other images will be produced from the same *thāsā*. A model produced in only one or two copies is obviously more expensive and I understand that the professional artificial ageing of a statue may cost up to 100 U.S. dollars, but the investment must be worthwhile for some dealers are ready to pay.

Western collectors should be particularly supicious of black or green corroded "Tibetan" metal images, for anyone who is familiar with the way they are kept ought to be aware of the generally good state of preservation of their surface. Tibetans have a less physical contact with their images than Newars and seem to regard the direct application of offerings to their surface as not far short of sacrilege. A good example of the contrasting Tibetan and Newar attitudes towards Buddhist images kept in Tibetan monasteries of the Nepal Valley is provided by Kuber Singh Sakya's 360 cm high fire-gilded copper repoussé Sha-kya-thub-pa (plate 15) which in about 1975 had to be protected by glass panels from the offerings thrown at it by Newar devotees. Drier climatic conditions in Tibet, where precipitation is generally less than 25 cm per year, also contribute to the better preservation of metal images there than is the case in the Nepal Valley, where they are exposed to the intense dampness of the monsoon; from July to September the Valley receives most of the annual rainfall of 127 cm to 140 cm. Thus, as a rule, Tibetan antiques are in a better state of preservation than forgers would have us believe.

The problem of establishing whether Newar metal images are ancient or modern is sometimes difficult. Newar statues are quickly worn by worshipping and the organic ritual substances deposited on them do not provide a clue to dating by chemical or carbon-14 analysis because their application is perfectly compatible with contemporary worship. Furthermore, it is doubtful whether antiqued gilded images will retain sufficient traces of ammonium chloride on their surface to be detected by chemical analysis. It is likely that the considerable demand for Himalayan antiques will lead to the perfecting of artificial ageing methods, particularly as far as Newar statuary is concerned, and especially where those methods are encouraged and supervised, if not actually practised, by Western dealers.

Conclusions

Apart from the methods of forgery, it appears that very few technological innovations have occurred in the statuary techniques used by Tibetan and Himalayan sculptors to this day. They still manufacture their own modelling tools and they model clay and wax in a traditional manner. Their investment techniques find a parallel in the use of different grades of clay as described in various Indian texts (Reeves, 1962:31), including the *Mānasollāsa*. Apart from the use of coal, the only improvement made in firing the mould and melting the metal is the modern use of electric fans and blowers by some sculptors, instead of hand-operated bellows. No innovation has been applied to the seemingly difficult problem of measuring the temperature of the clay mould before pouring the molten metal into it. Artists obviously feel confident enough to rely exclusively on their own experience.

Casting of separate parts of the same statue is not a novelty, as is shown by the instance of the Sultanganj Buddha. Occasionally medium size statues, whether hollow or solid, may still be cast in one piece (Alsop and Charlton, 1973:38). A few minor changes have occurred in the fitting techniques; tenons tend to be bigger than in the past and can no longer be bent, and split-pins are no longer used. However, examples of unsecured base in ancient statuettes are not rare. Brazing and silver-soldering are nowadays used to repair minor mis-castings and both techniques appear to have been introduced in Newar statuary after 1975. However, chasing, engraving, inlaying and gilding are still carried out with the traditional techniques, and it may thus be concluded that Himalayan metal statuary has undergone few technical changes since it was introduced into Tibet from India and Nepal and that it is still practised by ancient methods by Newar sculptors in Pātan.

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MAÑJUŚRĪ

Western Tibet. 11th-12th century A.D. Brass image and arsenical copper base. Ht. 12.5 cm. Pub.: von Schroeder, 1981 O.A. 1905. 5-19.15.

By the courtesy of the Trustees of the British Museum·

MAITREYA (?)

18th-19tn century A.D. Brass with red pigment on lips; imitation gold paint on front of figure. Ht. 8.6 cm. O.A. 1924.6-20.10.

By the courtesy of the Trustees of the British Museum

TĀRĀ

Nepal. A.D. 1975. Brass. Modelled by Babu Kaji Vajracarya; engraved by Rudra Bahadur Sakya. Ht. 16.5 cm Victoria and Albert Museum. I.S. 21-1980

Bibliography

Agrawal, D.P., (1971). *The Copper Bronze Age ın India*, New Delhi.

Allan, J.W., (1979). *Persian Metal Technology 700-1300 AD*, London.

Allchin, F.R., (1962). Upon the antiquity and methods of gold mining in ancient India, *Journal of the Economic and Social History of the Orient*, *5* 195-211.

Alsop, I. and Charlton, J., (1973). Image Casting in Oku Bahal, *Journal of Institute of Nepal and Asian Studies*, *1* (1) 22-49.

Anon, (1831). Native copper smelting at Singhara, *Gleanings in Science*, *3* (3) 380-84.

Ardussi, J., (1977). *Bhutan before the British. A Historical Study.* (Unpublished Ph. D. thesis). Canberra: Australian National University.

Aris, M., and Aung San Suu Kyi (eds.), (1980). *Tibetan Studies in Honour of Hugh Richardson*, Warminster.

Ashbee, C.R., (1967). *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture*, New York.

Asher, F.M., (1980). *The Art of Eastern India 300-800*, Minneapolis.

Bachmann, H.G., (1980). "Early copper smelting techniques in Sinai and in the Negev as deduced from slag investigations", in *Scientific Studies in Early Mining and Extractive Metallurgy*, (ed. P.T. Craddock), London: British Museum Occasional Paper No.20, pp.103-34.

Bailey, F.M., (1957). *No Passport to Tibet*, London.

Ball, V., (1881). *A Manual of the Geology of India, part 3, Economic Geology*, Calcutta: Geological Survey.

Barnard, N., (1961). *Bronze Casting and Bronze Alloys in Ancient China*, Canberra: Monumenta Serica Monograph XIV.

Barnes, J.W., (1973). Ancient clay furnace bars from Iran, *Bulletin of the Historical Metallurgy Group*, *7* (2) 8-17.

Beal, S., (1884). *Si-yu-ki: Buddhist Records of the Western World* (2 vols), London.

Beckwith, C.I., (1977). Tibet and the Early Medieval *Florissance* in Eurasia, *Central Asiatic Journal*, *21* 89-104.

(1980). "The Tibetan Empire in the West", in Aris and Aung, *op. cit.*, pp.30-8.

Béguin, G., (1977). *Dieux et démons de l'Himâlaya, art du Buddhisme lamaïque*, Paris: Musées nationaux.

Bell, C., (1927). *Tibet: Past and Present*, London.

(1968 repr.). *The People of Tibet*. Oxford.

Berglie, P-A., (1980). "Mount Dargo and Lake Tangra", in Aris and Aung, *op. cit.*, pp.39-44.

Bhardwaj, H.C., (1979). *Aspects of Ancient Indian Technology*, Delhi.

Bhattacharya, A.K., (1979). "A Study in Technique" and "A note on Chemical Analyses of the Alloy", in *East Indian Bronzes*, (ed. S.K. Mitra), Calcutta: Calcutta University, pp.61-72 and 146-7.

Bhattasali, N.K., (1972 repr.). *Iconography of Buddhist and Brahmanical Sculptures in the Dacca Museum*, Delhi.

Bhowmik, S., (1964). Technical Study and conservation of a Nepalese metal image from the Baroda Museum, *Journal of the Oriental Institute*, *13* (4) 393-8.

Biringuccio, V., (1966). *The Pirotechnia* (trans. and ed. by C.S. Smith and M.T. Gnudi), Massachusetts.

Bista, D.B., (1978). "Nepalis in Tibet", in *Himalayan Anthropology. The Indo-Tibetan Interface*, (ed. J.F. Fisher), The Hague and Paris, pp.187-204.

Bonvalot, G., (1891). *Across Thibet*, (Vol. 2), London.

Bose, D.M., (ed.), (1971). *A Concise History of Science in India*, New Delhi: Indian National Science Academy.

Brown, J.C., and Dey, A.K., (1955). *India's Mineral Wealth*, Bombay.

Brown, M.A., and Blin-Stoyle, A.E., (1959). A Sample Analysis of British Middle and Late Bronze Age Materials using Optical Spectrometry, *Proceedings of the Prehistoric Society*, *25* 188-209.

Bruce-Gardner, R.H., (1975). Gold embedded in Nepalese Mandala Scroll Paintings, *Burlington Magazine*, *117* (867) 378-81.

Buchanan, F.B., (1819). See Buchanan Hamilton, F.

Buchanan Hamilton, F., (1819). *An Account of the Kingdom of Nepal*, Edinburgh.

Burnam, J.M., (1920). *A Classical Technology edited from Codex Lucensis, 490*, Boston.

Candler, E., (1905). *The Unveiling of Lhasa*, London.

Caley, E.R., (1964). *Orichalcum and Related Ancient Alloys*, New York: American Numismatic Society Notes and Monographs No.151.

Carus, H.D., (1960). "Historical Background", in *Zinc*, (ed. C.H. Mathewson), New York: American Chemical Society, pp.1-8.

Casal, J.M., (1961). *Fouilles de Mundigak I*. Paris: Délégation Archéologique Française en Afganistan, esp. pp.244-51.

Chandra, L., (ed.), (1970). *Klongtrul's Encyclopaedia of Indo-Tibetan Culture* (parts 1-3), New Delhi.

Chandra, L., (1971). *An Illustrated Tibeto-Mongolian Materia Medica of Ayurveda of 'Jam-dpal-rdo-rje of Mongolia*, New Delhi.

(1973). *The Collected Works of Longdol Lama* (parts 1-2), New Delhi.

Chard, C.S., (1973). *North East Asia in Prehistory*, Wisconsin.

Charles, J.A., (1975). Where is the Tin? *Antiquity*, *49* 19-24.

Chase, W.T., (1973). Examination of art objects in the Freer Gallery Laboratory, *Ars Orientalis*, *9* 79-88.

Chattopadhyaya, D., (ed), (1970). *Taranatha's History of Buddhism in India*, Simla: Indian Institute of Advanced Studies.

Chikashige, M., (1920). The composition of ancient eastern bronzes, *Journal of the Chemical Society*, *117* 917-22.

Childe, V.G., (1953). The socketed celt in Upper Eurasia, *Annual Report of the Institute of Archaeology of London University*, *10* 11-25.

Clarke, G., (1977). Who were the Dards? *Kailash*, *5* 323-56.

Coales, O., (1919). Economic Notes on Eastern Tibet, *The Geographical Journal*, *54* (4) 242-7.

Coghlan, H.H., (1976). *Notes on the Prehistoric Metallurgy of Copper and Bronze in the Old World*, Oxford: Pitt Rivers Museum Occasional Paper on Technology No.4 (2nd edn.).

Collins, A.L., (1894). The Ghorband lead mines, Afghanistan, *Transactions of the Federal Institution of Mining Engineers*, *6* (3) 449-56.

Conrad, H.G. and Rothenberg, B., (1980). *Antikes Kupfer im Timna-Tal*, Bochum: Deutsches Bergbau Museum.

Cooper, T.T., (1871). *Travels of a Pioneer of Commerce in Pigtail and Petticoats*, London.

Cowell, M.R., (1977). Energy dispersive X-ray fluorescence analysis of ancient gold alloys, *PACT* (Journal of the European Study Group on Physical, Chemical and Mathematical Techniques Applied to Archaeology), *1* 76-85.

Craddock, P.T., (1977). The composition of copper alloys used by the Greek, Etruscan and Roman civilizations. 2. The Archaic, Classical and Hellenistic Greeks, *Journal of Archaeological Science*, *4* 103-23.

(1978). The composition of copper alloys used by the Greek, Etruscan and Roman civilizations. 3. The Origins and Early Use of Brass, *Journal of Archaeological Science*, *5* 1-16.

(1979). The Copper alloys of the Medieval Islamic World - inheritors of the classical tradition, *World Archaeology*, *11* 68-79.

Craddock, P.T., (1980). "The Composition of copper produced at the ancient smelting camps in the Wadi Timna, Israel", in *Scientific Studies in Early Mining and Extractive Metallurgy* (ed. P.T. Craddock), London: British Museum Occasional Paper No.20, pp.165-73.

(1981). Corinthian Bronze - Rome's purple sheen gold, *MASCA Journal, 1* (forthcoming).

Craddock, P.T.,Burnett, A.M. and Preston, K., (1980). "Hellenistic copper-base coinage and the origins of brass", *Scientific Studies in Numismatics*, (ed. W.A. Oddy), London: British Museum Occasional Paper No.18, pp.53-64.

Dagyab, L.S., (1977). *Tibetan Religious Art*, (2 vols.), Wiesbaden.

Dalai Lama (XIVth), (1970). *The Tibetan Cathedral Thekchen Chholing, Dharmasala, Himachal Pradesh*, Dharmasala: Office of Private Secretary to H.H. The Dalai Lama.

Dani, A.H., (1959). *Buddhist Sculpture in East Pakistan*, Karachi: Department of Archaeology.

Das, S.C., (1904). *Journey to Lhasa and Central Tibet*, London.

(1976 repr.). *A Tibetan-English Dictionary*, Delhi.

Dawkins, J.M., (1950). *Zinc and Spelter*, Oxford: Zinc Development Association.

Day, J., (1972). *Bristol Brass: The History of the Industry*, Newton Abbot.

Dayton, J., (1971). Problems of Tin in the Ancient World, *World Archaeology, 3* 49-70.

De Filippi, F., (ed.),(1937). *An Account of Tibet. The Travels of Ippolitc Desideri of Pistoia, S.J.,. 1712-1727*, London.

De Jesus, P.S., (1978). "Considerations of the occurence and exploitation of tin sources in the ancient Near-east", in *The Search for Ancient Tin*, (eds. A.D. Franklin, J.S. Olin and T.A. Wertime), Washington: Smithsonian Institution, pp.33-8.

Demiéville, P., (1952). *Le concile de Lhasa*, Paris.

Denwood, P., (1973). A Greek Bowl from Tibet, *Iran, 9* 121-7.

Draper, M.D., (1931). The Tin Industry of Yunnan, *Far East Review, 5* 483-91.

Duncan, M.H., (1964). *Customs and Superstitions of Tibetans*, London.

Eaton, E.R., and McKerrell, H., (1976). Near Eastern Alloying and evidence for the early use of arsenical copper, *World Archaeology, 8* 169-91.

Ekvall, R.B., (1968). *Fields on the Hoof: Nexus of Tibetan Nomadic Pastoralism*, New York.

Farsnsworth, M., Smith, C.S. and Rodda, J.L., (1949). Metallographic examination of a sample of metallic zinc from ancient Athens, *Hesperia*, (Supplement 8) 126-9

Fergusson, W.N., (1911). *Adventure, Sport and Travel on the Tibetan Steppes*, London.

Ferrari, A., (1958). *mKhyen brtse's Guide to the Holy Places of Central Tibet*, Rome.

Forbes, R.J., (1964, 2nd edn. 1971). *Studies in Ancient Technology*, (volume 8), Leiden.

Franke, A.H., (1977). *A History of Ladakh*, New Delhi.

Franklin, A.D., Olin, J.S., and Wertime, T.A., (eds.), (1978). *The Search for Ancient Tin*, Washington: Smithsonian Institution.

Gibbs, F.W., (1957). "Invention in Chemical Industries", in *A History of Technology*, volume 3: *From the Renaissance to the Industrial Revolution* (eds. C. Singer, E.J. Holmyard, A.R. Hall and T.I. Williams), Oxford, pp.676-708, esp. 690-1.

Gill, W., (1883). *The River of Golden Sand*, London.

Giorgi, A.A., (1762). *Alphabetum Tibetanum*, Roma: Typis Sacrae Congregationis de Propaganda Fide.

Goetz, H., (1969). *Studies in the History and Art of Kashmir and the Indian Himalaya*, Wiesbaden.

Gopal, L., (1965). *The Economic Life of Northern India, c. AD. 700-1200*, Delhi.

Gorè, F., (1923). Note sur les Marches tibétaines du Sseu-tch'ouan et du Yunnan, I. Les Marches tibétaines du Sseu-tch'ouan, *Bulletin de l'Ecole Française d'Extrême-Orient*, *23* 319-59.

Govinda, L.G., (1979). *Tibet in Pictures*, (2 vols), Berkeley.

Gowland, W., (1896). Japanese Metallurgy - Part 1 - Gold and silver and their alloys, *Journal of the Society of Chemical Industry*, *15* 404-14.

(1914-1915). Metals and metal-working in Old Japan, *Transactions and Proceedings of the Japan Society of London*, *13* 20-99.

Gluek, N., (1965). Ezion-Geber, *Biblical Archaeologist*, *28* 70-87.

Guibaut, A., (1949). *Tibetan Venture*, London.

Gutman, P., (1979). Crowned Buddha images of Arakan, *Art and Archaeology Research Papers*, *15* 48-56.

Haedecke, K.,(1973). Gleichgewichtsverhältnisse bei der Messingherstellung nach dem Galmeiverfahren, *Erzmetall*, *26* 229-33.

Halleux, R., (1973). L'orichalque et le laiton, *Antiquité classique, 42* 64-81.

Harley, R.D., (1970). *Artists' Pigments c. 1600-1835,* London.

Hassnain, F.M. *et al.*, (1977). *Ladakh: The Moonland,* New Delhi.

Hatt, R.T., (1980). A thirteenth century Tibetan reliquary, *Artibus Asiae*. *42* (2-3) 175-220.

Hawthorne, J.G. and Smith, C.S., (eds.), (1963). *On Divers Arts, the Treatise of Theophilus,* Chicago, (reprinted New York, 1979).

Healey, J.F., (1978). *Mining and Metallurgy in the Greek and Roman World,* London.

Hedin, S., (1910). *Trans-Himalaya,* Vol. I, London.

(1922). *Southern Tibet,* (9 vols.), Stockholm.

Hegde, K.T.M., (1978). "Sources of ancient tin in India", in *The Search for Ancient Tin,* (eds. A.D. Franklin, J.S. Olin and T.A. Wertime), Washington: Smithsonian Institution.

Hindustan Zinc Ltd., (n.d.). Leaflet entitled *Rajpura-Dariba Mines.*

Hodgson, B.H., (1874, repr. 1972). *Essays on the Languages, Literature and Religion of Nepal and Tibet,* Amsterdam.

Holmyard, E.J., (1957). *Alchemy,* Harmondsworth.

Hours, M., (ed.), (1980). *La vie mystérieuse des chefs-d'oeuvre - la science au service de l'art,* Paris: Réunion des Musées Nationaux, pp.95-8: Le bodhisattva Vajrapani.

Hübotter, F., (1957). *Chinesisch-Tibetische Pharmakologie und Rezeptur,* Ulm-Donau.

Huc, R.E., (1924). *Souvenirs d'un voyage dans la Tartarie et le Thibet pendant les années 1844, 1845 et 1846,* (2 vols.), Peking.

Hughes, M.J., Cowell, M.R. and Craddock, P.T., (1976). Atomic absorption techniques in archaeology, *Archaeometry, 18* 19-38.

Imperial Gazetteer of India, (1908). *Afghanistan and Nepal,* Calcutta.

Itsikson, M.I., (1960). Distribution of tin-ore deposits within folded zones, *International Geology Review, 2* 397-417.

Jackson, D. and J., (1976). A survey of Tibetan pigments, *Kailash, 4* (3) 273-94.

Jackson, J.S., (1980). "Metal Ores in Irish Prehistory: Copper and Tin", in *Origins of Metallurgy in Atlantic Europe,* (ed. M. Ryan), Dublin: National Museum of Ireland.

Jäschke, H.A., (1972 repr.). *A Tibetan-English Dictionary,* London.

Jones, R.S. and Fleischer, M., (1969). *Gold Minerals and the Composition of Native Gold*, Washington: Geological Survey Circular 612.

Jones, T.L., (1968). Strabo, *Geography* Book XIII, 56, London, Heinemann (Loeb Classical Library).

Kangle, R.P., (1963). *The Kautilīya Arthaśāstra: Part II; An English Translation with . . notes*, Bombay.

(1965). *The Kautilīya Arthaśāstra: Part III; A Study*, Bombay.

Karmay, H., (1975). *Early Sino-Tibetan Art*, Warminster.

Karsten, J., (1980). "Some notes on the house of lHa rGya-ri" in Aris and Aung, *op. cit.*, pp.163-8.

Kawaguchi, E., (1909). *Three Years in Tibet*, Madras, Benares and London.

Khandalavala, K., (1950). Some Nepalese and Tibetan Bronzes in the Collection of Mr R.S. Sethna of Bombay, *Marg*, *4* (1) 21-40.

Kirkpatrick, W., (1975 repr.). *An Account of the Kingdom of Nepal*, Delhi.

Klong-rdol-bla-ma, (1973). *The Collected Works of Longdol Lama*, (parts I and II), New Delhi: International Academy of Indian Culture. Sata-pitaka No. 100

Kramrisch, S., (1964). *The Art of Nepal*, (catalogue), New York.

Krenkow, F., (ed.) (1936). al-Birūnī, *Kitāb al-jamāhir fī ma'rifat al-jawāhir*, Hyderabad.

Krishnan, M.V., (1976). *Cire Perdue Casting in India*, New Delhi.

Kuznetsov, B.I., (ed.)(1966). *rGyal rabs gsal ba'i me long*, Leiden.

Labriffe, M-L. de, (1973). Etude de la fabrication d'une statue au Népal, *Kailash*, *1* (3) 185-92.

Lal, B.B., (1956). An examination of some metal images from Nalanda, *Ancient India*, *12* 53-7.

Landon, P., (1905). *Lhasa*, (2 vols), London.

Laufer, B., (1918). *Loan-Words in Tibetan*, Leiden.

Lee, S.E., (1967). Clothed in the Sun: a Buddha and a Surya from Kashmir, *Bulletin of the Cleveland Museum of Art*, February, pp.42-50.

Leeds, E.T., (1955). Zinc coins in Medieval China, *Numismatic Chronicle*, *14* (6th series) 177-85.

Levey, M., (1962). Medieval Arabic bookmaking and its relation to early chemistry and pharmacology, *Transactions of the American Philosophical Society*, *52* (new series) (part 4).

Lévi, S., (1905). *Le Népal*, (3 vols), Paris.

Lins, P.A. and Oddy, W.A., (1975). The origins of mercury gilding, *Journal of Archaeological Science*, *2* 365-73.

Lo Bue, E., (1978). Buddhist Himalayan Art in the XXth Century, *Himalyan Culture, 1* (1) 19-35.

(1981). Himalayan Sacred Art in the 20th Century, *Art International, 24* (5-6) 114-27.

(thesis 1981). *Himalayan Sculpture in the XXth Century: a study of the religious statuary in metal and clay of the Nepal Valley and Ladakh,* (S.O.A.S., University of London).

Lowell, T.Jr., (1951). *Out of this World-across the Himalayas to Tibet,* London.

Lowry, J., (1973). *Tibetan Art,* London.

McGovern, W.M., (1924). *To Lhasa in Disguise,* London.

McKerrell, H., (1977). Non-dispersive XRF applied to ancient metalworking in copper and tin bronze, *PACT* (Journal of the European Study Group on Physical, Chemical and Mathematical Techniques applied to Archaeology), *1* 138-73.

Macdonald, D., (1932). *Twenty Years in Tibet,* London.

Mactear, J., (1894). Some notes on Persian mining and metallurgy, *Transactions of the Institution of Mining and Metallurgy, 3* 2-39.

Maddin, R., Wheeler, T.S., and Muhly, J.D., (1980). Distinguishing artifacts made of native copper, *Journal of Archaeological Science, 7* 211-27.

Majumdar, N.G., (1926). A Gold-Plated Bronze from Mahasthan, *The Modern Review, 40* 425-7.

Markham, C.R., (1879). *Narratives of the Mission of George Bogle to Tibet, and of the Journey of Thomas Manning to Lhasa,* London.

Marshall, J., (1951). *Taxila,* (3 vols), Cambridge.

Masefield, J. and Rhys, E. (eds.), (1936 repr.). *The Travels of Marco Polo,* London.

Masson, V.M., and Sarianidi, V.I., (1972). *Central Asia,* London.

Mathew, R.H., (1969). *Chinese-English Dictionary,* Cambridge: Harvard University Press.

Mathewson, C.H., (1960). *Zinc,* New York: American Chemical Society.

Mellaart, J., (1967). *Çatal Hüyük: a Neolithic Town in Anatolia,* London.

Merrifield, M.P., (1849). *Original Treatises on the Arts of Painting,* London.

Mills, J.W. and Gillespie, M., (1969). *Studio Bronze Casting,* London.

Montell, G., (1954). The idol factory of Peking, *Ethnos, 19* (1-4) 143-56.

Moran, S.F., (1969). The gilding of ancient bronze statues in Japan, *Artibus Asiae, 31* (1) 55-65.

Muhly, J.D., (1973). *Copper and Tin,* Hamden (Connecticut), esp. 234-8.

Nadkarni, K.M., (1954). *Indian Materia Medica,* (Vol. II), Bombay.

Nash, W.G., (1904). *The Rio Tinto Mine, its History and Romance,* London, esp. 178.

Needham, J., (1974). *Science and Civilization in China. Vol. 5: Chemistry and Chemical Technology. Part II,* Cambridge.

(1976). *Science and Civilization in China. Vol. 5: Chemistry and Chemical Technology. Part III,* Cambridge.

(1980). *Science and Civilization in China. Vol 5: Chemistry and Chemical Technology. Part IV,* Cambridge.

Nepali, G.S., (1965). *The Newars,* Bombay.

Neven, A. *et al.,* (1975). *Lamaistic Art,* Bruxelles.

Norbu, T.J. and Turnbull, C., (1972). *Tibet, its History, Religion and People,* Harmondsworth.

Oddy, W.A., and Meeks, N.D., (1978). A Parthian bowl: study of the gilding technique, *MASCA Journal, 1* 5-6.

Oddy, W.A., Borrelli Vlad, L., and Meeks, N.D., (1979). "The gilding of bronze statues in the Greek and Roman World", in *The Horses of San Marco, Venice,* London: Royal Academy.

Oddy, W.A., (1981). Gilding through the ages: an outline history of the process in the Old World, *Gold Bulletin, 14* (2) 75-9.

(1981). Scientific dating of the San Marco Horses? *MASCA Journal 1* (8) (forthcoming).

(in press). Diffusion-bonding as a method of gilding in Antiquity, *MASCA Journal.*

Olsen, E., (ed), (1975 repr.). *Catalogue of the Tibetan Collection and other Lamaist Material in the Newark Museum,* (vol. 4), Newark (N.J).

Padma-dkar-po, (1973 repr.). *Collected Works,* Darjeeling.

Pal, P., (1975). *Bronzes of Kashmir,* Graz.

(1974). Bronzes of Nepal, *Arts of Asia. 4* (5) 31-37.

(1969). *The Art of Tibet,* (catalogue), New York.

(1974). *The Arts of Nepal. Part I. Sculpture,* Leiden and Köln.

(1970). *Vaiṣṇava Iconology in Nepal,* Calcutta: The Asiatic Society.

Pemberton, R.B., (1961 repr.). *Report on Bootan.* Calcutta: Indian Studies Past and Present.

Percy, J., (1861). *Metallurgy: Fuel, Fire Clays, Copper, Zinc and Brass.* London.

Pereira, F.M.E., (1926). *O Descombrimento do Tibet pelo P. Antonio de Andrade da Companhia de Jesus,* Coimbra.

Petech, L., (1973). *Aristocracy and Government in Tibet 1728-1959,* Rome: Is.M.E.O.

(1958). *Medieval History of Nepal (c. 750-1480),* Rome: Is. M.E.O.

(1977). *The Kingdom of Ladakh. c. 950-1842 A.D.,* Rome: Is. M.E.O.

Piddington, H., (1854). Examination and analyses of Dr Campbell's specimens of copper ores obtained in the neighbourhood of Darjeeling, *Journal of the Asiatic Society of Bengal 23* (5) (new series) 477-9.

Ponchiroli, D., (ed.) (1979). *Il Libro di Marco Polo detto il Milione,* Torino.

Prakash, S. and Rawat, N.S., (1965). *Chemical Study of Some Indian Archaeological Antiquites,* Lucknow.

Pranavananda, S., (1939). *Exploration in Tibet,* Calcutta: University of Calcutta.

Rackham, H., (1952). *Pliny: Natural History. Vol IX,* London: Heinemann (Loeb Classical Library).

Rajpitak, W. and Seeley, N.J., (1979). The bronze bowls from Ban Don Ta Phet, Thailand: an enigma of prehistoric metallurgy, *World Archaeology, 11* 26-31.

Ray, A.P.C., (1903). *A History of Hindu Chemistry,* Vol. I, Calcutta.

(1909). *A History of Hindu Chemistry,* Vol. II, London.

Ray, P., (1956). *History of Chemistry in Ancient and Medieval India,* Calcutta: Indian Chemical Society.

Read, J., (1939). *Prelude to Chemistry,* London.

Reeves, R., (1962). *Cire Perdue Casting in India,* New Delhi: Crafts Museum.

Regmi, D.R., (1961). *Modern Nepal,* Calcutta.

(1971). *A Study in Nepali Economic History,* New Delhi.

Rhodes, N.G., (1980). "The development of currency in Tibet", in Aris and Aung, *op. cit.*, pp.261-8.

Richardson, H., (1977). "The Jo-khang 'Cathedral of Lhasa'", in *Essais sur l'art du Tibet,* (eds. A. Macdonald and Y. Imaeda) Paris. pp. 157-88.

Riederer, J., (1979). "Zur Metallanalyse der Statuetten", in *Das Bild des Buddha*, (ed. H.Uhlig), Berlin.

Rockhill, W.W., (1891). *The Land of the Lamas*, London.

(1894). *Diary of a Journey through Mongolia and Tibet in 1891 and 1892*, Washington: Smithsonian Institution.

Roerich, G.N., (ed.),(1976 repr.). *The Blue Annals*, Delhi.

Ronge, V., (1978). *Das Tibetische Handwerkertum vor 1959*, Wiesbaden.

Ronge, V. and Ronge, N.G., (1980). "Casting Tibetan bells" in Aris and Aung, *op. cit.*, pp.269-76.

Rothenberg, B., (1972). *Timna, Valley of the Biblical Copper Mines*, London.

Ruelius, H., (1974). *Śāriputra und Ālekhyalakṣaṇa*, Göttingen: Göttingen University.

Sahai, B., (1977). The Metallic Composition of the Bronzes from Bihar. *The Journal of the Bihar Puravid Parishad, 1* 231-40.

Sandberg, G., (1904). *The Exploration of Tibet*, Calcutta.

Saraswati, S.K., (1936). An ancient text on the casting of metal images, *Journal of the Indian Society of Oriental Art, 4* 139-44.

(1962). *Early Sculpture of Bengal*, (2nd edn.),Calcutta.

Schroeder, U. von, (1981). *Indo-Tibetan Bronzes*, Hong Kong.

Shakabpa, W.D., (1967). *Tibet: A Political History*, New Haven and London.

Shukla, D.N., (1958). *Vastusastra, Vol. II. Hindu Canons of Iconography and Painting*, Gorakhpur: Gorakhpur University.

Shamasastry, R., (1967). *Kauṭilya's Arthaśāstra*, (8th edn.), Mysore.

Singh, M., (1971). *Himalayaṇ Art*, London.

Sís, V. and Vaniš, J., (n.d.[1957]). *On the Road through Tibet*, London.

Smith, E.G., (1969). *Tibetan Catalogue* (Part 1), Seattle.

Smith, C.S.,(1973). "An examination of the arsenic-rich coating on a bronze bull from Horoztepe", in *Applications of Science in Examination of Works of Art*, (ed. W.J. Young), Boston: Museum of Fine Arts.

Smith, C.S. and Hawthorne, J.G., (1974). Mappae Clavicula: A Little Key to the World of Medieval Techniques, *Transactions of the American Philosophical Society, 64* (new series) (part 4).

Snellgrove, D. and Richardson, H., (1968). *A Cultural History of Tibet*, London.

Snellgrove, D. and Skorupski, T., (1977-1980). *The Cultural Heritage of Ladakh* (2 vols.), Warminster.

Solheim II, W.G., (1972). Early Man in S.E. Asia, *Expedition, 14* (3) 25-31.

Sperling, E., (1980). "The 5th Karma-pa and some aspects of the relationship between Tibet and Early Ming", in Aris and Aung, *op. cit.*, pp.280-9.

Spooner, D.B., (1915). "Vishnu images from Rangpur" in *Archaeological Survey of India, Annual Report 1911-12,* Calcutta, pp.152-8.

Stein, M.A., (1900). *Kalhana's Rājataranginī, a chronicle of the kings of Kashmir,* Westminster.

Stein, R.A., (1962). *La Civilisation tibêtaine,* Paris.

Subbarayappa, B.V., (1971). "Chemical practices and alchemy", in Bose, D.M., *op. cit.*

Suwal, P.N., (ed.), (1970). Medicinal plants of Nepal, *Bulletin of the Department of Medicinal Plants, 3,* Kathmandu.

Teichman, E., (1922). *Travels of a Consular Officer in Eastern Tibet,* Cambridge.

Thomas, L., Jr., (1951). *Out of this World,* London.

Trotter, H., (1877). Account of the Pundit's journey in Great Tibet from Leh in Ladakh to Lhasa, and of his return to India via Assam, *The Journal of the Royal Geographic Society, 47* 86-136.

Tucci, G., (1933). *Indo-Tibetica. Vol. II. Rin c'en bZaṅ po e la rinascita del buddhismo nel Tibet intorno al mille,* Roma: Reale Accademia d'Italia.

(1935). *Indo-Tibetica. Vol III. I templi del Tibet Occidentale e il loro simbolismo artistico.* (Pt. 1). *Spiti e Kunavar,* Roma.

(1937). *Santi e Briganti nel Tibet ignoto,* Milano.

(1949). *Tibetan Painted Scrolls,* (3 vols.), Rome.

(1952). *A Lhasa e oltre,* Roma: La Libreria dello Stato.

(1956). *Preliminary Report on Two Scientific Expeditions in Nepal,* Roma: Is.M.E.O.

(1959). A Tibetan classification of Buddhist images according to their style, *Artibus Asiae, 22* 179-87.

Turner, S., (1800). *Ambassade au Thibet et au Boutan,* Paris.

(1800). *An Account of an Embassy to the Court of the Teshoo Lama, in Tibet,* London.

Tylecote, R.F., (1962). *Metallurgy in Archaeology,* London.

(1976). *A History of Metallurgy,* London: The Metals Society.

Tylecote, R.F., Ghaznavi, H.A. and Boydell P.J., (1977). Partitioning of trace elements between the ore, fluxes, slags and metals during the smelting of copper, *Journal of Archaeological Science, 4* 305-33.

Tylecote, R.F. and Boydell, P.J., (1978). "Experiments on Copper Smelting", in *Chalcolithic Copper Smelting*, (ed. B. Rothenberg), London: Institute for Archaeo-metallurgical Studies Monograph No. 1.

Uhlig, H.,(ed.),(1979). *Das Bild des Buddha*, (catalogue), Berlin.

Vittori, O., (1978). Interpreting Pliny's gilding: archaeological implications, *Rivista di Archeologia*, *2* 71-81.

(1979). Pliny the Elder on gilding, *Gold Bulletin*, *12* (1) 35-9.

Waddell, L.A., (1906). *Lhasa and its Mysteries*, London.

Wagner, G.A., Gentner, W., Gropengiesser, H., and Gale, N.H., (1980). "Early Bronze Age lead-silver mining and metallurgy in the Aegean: The ancient workings on Siphnos," in *Scientific Studies in Early Mining and Extractive Metallurgy*, (ed. P.T. Craddock), London: British Museum Occasional Paper No. 20, pp.63-85.

Waldschmidt, E. and R.L., (1969). *Nepal. Art Treasures from the Himalayas*, London.

Walsh, E.H.C., (1938). The image of Buddha in the Jo-wo-Khang temple at Lhasa, *Journal of the Royal Asiatic Society*, 535-40.

(1946). Lhasa. *Journal of the Royal Asiatic Society*, 23-31.

Wang-Chin, (1923). The Composition of Wu-Chu coinage and the examination of ancient pewter, *K'o-hsüeh*, *8* 839-51.

Watters, T., (1905). *On Yuan Chwang's Travels to India*, (2 vols.), London.

Werner, O., (1970). Über das Vorkommen von Zink und Messing im Altertum und im Mittelalter, *Erzmetall*, *23* 259-69.

(1972). *Spektralanalytische und Metallurgische Untersuchungen an Indischen Bronzen*, Leiden.

White, J.C., (1971). *Sikhim and Bhutan*, Delhi.

Wylie, T.V., (1962). *The Geography of Tibet according to the 'Dzam-gling-rgyas-bshad*, Rome.

Ya'ḳūbī (Aḥmad ibn Abī Ya'qūb ibn Wāḍiḥ: al Ya'qūbī), (1937). *Les Pays*, Cairo.

NOTES AND TOPICS WITH ACKNOWLEDGEMENT

In this issue of Bulletin of Tibetology, we are reproducing two articles of Dr. Erberto Lo Bue. The first article deals with the history, tradition and modern use of metallurgy in Tibet and the Himalayas. The second article deals with the history, tradition and modern technique in casting of devotional images in the Himalayas.

Only three illustrations with their descriptions are reproduced in the article :

(1) Illustration No. 42 (Mañjuśrī),
(2) Illustration No. 66 (Maitreya), and
(3) Illustration No. 121 (Tārā)

We are grateful to the British Museum for their kind permission to reproduce the above illustrations which we hope will benefit the traditional and modern scholars in their research into this field of study.

We owe much to Miss Marianne Winder for her kind co-operation and help.

J. K. Rechung

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