Smelting, forging and smithing: A brief history of metallurgy for the lexicographer

by
David Mead

2013

Sulang Language Data and Working Papers: Topics in Lexicography, no. 15

Sulawesi Language Alliance
http://sulang.org/

SulangLexTopics015

LANGUAGES

Language of materials : English

ABSTRACT

This paper covers metal and metal alloys along with the processes of smelting, forging and smithing. The discussion of English and Indonesian terms associated with metal and metalworking is set within a broad historical context, from the Bronze Age through the development of modern steel mills.

TABLE OF CONTENTS

VERSION HISTORY

Version 1 [14 May 2013] This paper originally circulated September 2008; revised May 2010; formatted for publication May 2013.

Smelting, forging and smithing:
A brief history of metallurgy for the lexicographer

by
David Mead

Have you ever stopped to wonder why the Bronze Age *had* to precede the Iron Age? You'll find the answer in this brief guide to metallurgy and metal working terms, geared toward the lexicographer in the Indonesian context.[1]

1 Smelting

> *There is a mine for silver,*
> *And a place where gold is refined;*
> *Iron is taken from the earth,*
> *And copper is smelted from ore.* Job 28:1–2

SMELTING (*meleburkan bijih*)[2] is the process of separating metal from ore by heating the ore until the metal within it turns liquid. Tin has a melting point of 449° F, which means you could smelt tin in a campfire. Copper has a higher melting point (1981°F), but even that was within the range of primitive, charcoal-fired SMELTING FURNACES (*peleburan*). The technology to smelt and cast copper has existed since around 3800 BC. Smelting and casting copper was much superior to the far older way of simply bashing nuggets of copper into the shape of crude tools.

2 Copper, bronze and brass

Although harder than gold or silver, copper is still a relatively soft metal, and copper tools worked about as well as their stone counterparts (though they lasted longer). The next major breakthrough came when people realized if they smelted copper and tin ores together, the resultant metal alloy—bronze—was far stronger and more useful. Thus began the Bronze Age, around 2800 BC.

Whereas bronze is an alloy of copper and tin, brass is an alloy of copper and zinc. Some people say that the Romans invented brass, but it would be more correct to say that they

---

[1] I am indebted to Michael Martens for his interaction on this paper at several levels, and especially for his spurring me on to look at other metals beyond iron. I would also like to thank Waruno Mahdi for reviewing this paper and suggesting several significant improvements.

[2] By itself, *meleburkan* variously means 'dissolve,' 'melt, make molten' (of metals), 'liquify' (as fats), and even 'wipe out,' hence the qualifier *bijih* 'ore' in order to restrict the sense to 'smelt.'

were the first to intentially produce brass. That is, the Romans were the first to recognize the difference between tin ore (stannite) and zinc ore (sphalerite), and they employed that knowledge to advantage. Up until then, so-called bronzes may or may not have included zinc in the alloy, and even today some low quality bronzes also include zinc, making them more brass-like in quality. In actuality, then, there is not as sharp a dividing line between 'brass' and 'bronze' as the English terms might imply. The folk notion that brass is yellow while bronze is golden brown is only partly true: brasses with high zinc content can be yellow (20%–38% zinc) or even silvery-white (up to 48% zinc), but brasses with lower zinc content are the color of some bronzes.

In the Malay context, there are five terms for copper and copper alloys (six if you include the borrowed word *kuprum*), and unlike the English terms which are based on chemical composition, the Malay words are based more on appearance. I am indebted to Waruno Mahdi (2007:pers.comm.) for his help in sorting out the Indonesian terms.

- *kuningan* = refers to copper alloys which are yellowish in color; it is sometimes also used in reference to copper (< Proto-Malayo-Polynesian *kuniŋ 'yellow' + *-an)
- *loyang* = refers explicitly to the light yellow alloys even more so than *kuningan* (the word *loyang* can also refer to a kind of tray, as well as cake molds, in the same way that English 'tin' is polysemous).[3]
- *tembaga* = narrowly, it refers to the chemical element copper (Cu), but it is also used for some copper alloys, though not so much for either the very dark ones or the lighter ones (< Sanskrit *tāmra* 'coppery-red color' via Prakrit *tambaka* or *tambaga*).
- *perunggu* = specifically refers to bronze, and is used to translate English 'bronze' in contexts such as *medali perunggu* 'bronze medal' and *Zaman Perunggu* 'Bronze Age.'
- *gangsa* = refers to the darker copper alloys, but is not as narrowly defined as *perunggu* (< Sanskrit *kaṃsa* 'brass,' cf. Old Javanese *kaṅsa* 'brass, bell metal' which preserved the voiceless consonant).
- *kuprum* = the chemical element copper (Cu) (< Latin *cuprum*, corruption of *cyprium* 'Cyprus').

The semantic range accorded to *tembaga* is seen in that it can also be used as the generic in certain compound expressions. These expressions include: *tembaga kuning* (= *kuningan*), *tembaga merah* (= copper) and *tembaga perunggu* (= *perunggu*) (Stevens and Schmidgall-Tellings 2004:s.v.).

---

[3] As the source of this word, Dempwolff (1938) reconstructed Proto-Malayo-Polynesian *luyang 'brass.' But as noted below in § 11, ascribing the meaning 'brass' to a word of this time depth is problematic. Either the meaning 'brass' is a secondary development, or else supposed cognates owe their distribution to later borrowing.

3 Distinguishing brass from bronze

For a while I was befuddled whether to describe certain metal objects as being made of bronze or brass. Objects made from a copper alloy which you may encounter in the Indonesian context potentially include:

helmets	shields	body armor [4]
bells	gongs	kettledrums
arm bands	bracelets	anklets, ankle rings
ear ornaments	head ornaments	rings worn above the calf
finger rings	axe heads	heads of bark cloth beaters [5]
trays	bowls & footed bowls	box for betel-nut ingredients

Unless an object is clearly yellowish, which would indicate brass, it is difficult to tell brass from bronze by simple inspection. Brass and bronze have very nearly the same specific gravity, thus one is not appreciably heavier than the other. Also, brass and bronze both develop a patina which can be rubbed off, or, said another way, become shiny in places where they are often rubbed. For those who wish to try, here are three possible tests,[6] though none is fullproof.

- An object which has been machine-worked is likely to be brass. Bronze objects tend to be cast only, and not further worked.
- Hold the object lightly by the edge and tap it with the end of a pencil. A bronze object will give a clearer ring. For example, the tones of a bronze gong will decay more slowly than those of a brass gong.[7]
- Drill a tiny hole into the object. If the shavings come out in long connected ‘strings’ it is bronze. If the shavings come out like powder, it is probably brass.

Of course, some people eschew this last test on grounds that it would do damage to the object under consideration.

Here are two other rules of thumb which I have gleaned. First, axe heads are likely to be bronze. Interestingly, bronze and steel axe heads work about equally well in the task of felling trees (Mathieu and Meyer 1997). Second, gongs made prior to World War II are likely to be bronze; conversely, gongs made after the war are likely to be brass. Whether this is also likely to be true of other objects, I do not know.

---

[4] Helmets, shields and body armor from the Portguese era could still be found in eastern Indonesia at the turn of the twentieth century, see particularly the summary (and illustrations) in Van Hoëvell (1908).

[5] Primarily on Java; in other places of Indonesia heads are (were) made of stone (Kennedy 1934:237).

[6] The first test should be a simple ‘magnet’ test to see if the object might be iron overlaid with a copper alloy.

[7] An object which gives a dull thud may in fact be plated, having a zinc core.

Here are my own suggestions. In Indonesian, use *perunggu* only if you are certain that an object is indeed bronze. Otherwise, use one of the terms *loyang*, *kuningan*, *tembaga* or *gangsa*, depending on color of the metal. Translate *loyang* and *kuningan* as 'brass' in English, but for *tembaga* and *gangsa* you will probably want to say something like 'brass or bronze.' You could also say simply 'bronze,' with the understanding that bronze is the broader of the two terms; at least, this is the way 'bronze' is used in the field of archaeology (William Ayres 2007:pers.comm.).

4 More copper alloys: tumbaga, pinchbeck and nickel silver

All that glitters is not gold,
Gilded tombs do worms enfold. William Shakespeare
Merchant of Venice, II vii

According to the *Kamus Besar* editors, *tembaga suasa*, or simply *suasa*,[8] is an alloy of gold and copper. By a twist of fate, the English term for this alloy is TUMBAGA, a word which entered the English language from Spanish via Tagalog through Malay and, as noted above, is ultimately from Sanskrit. Tumbaga has a lower melting point than either gold or copper alone. As South American Indians discovered, however, the primary utility of tumbaga is that when objects cast from tumbaga are subjected to vegetable acids (such as citric acid), the copper is leached away, leaving a thin coating of pure gold around an impure core—a process known as depletion gilding. Tumbaga alloys used in the past ranged from almost entirely (97%) gold, to almost entirely (97%) copper. Alloying of gold with copper was unknown in Asia or the West prior to Columbus's discovery of the New World (Marschall 1968:175 ff, cited in Blust 1992:447).

In the literature, I have seen copper-gold alloy mistakenly identified as pinchbeck. PINCHBECK is actually a particular copper-zinc alloy (that is, a kind of brass) which very nearly resembles gold in color. It is named after Christopher Pinchbeck, who according to tradition developed this alloy in England in the early eighteenth century. Pinchbeck was used as an inexpensive substitute for gold in jewelry and other objects.

As with gold, so also a way to make a 'silver substitute' by alloying copper, nickel and zinc was discovered, but this development originally occurred in China. Known in the West in the early eighteenth century by the Chinese name PAKTONG (literally 'white copper') or the Indian name TUTENAG, it later garnered the names NICKEL SILVER, GERMAN SILVER, NEW SILVER, ALPACCA and—possibly owing to its use as a substrate in electroplating—electrum. This last, however, was a misnomer.

---

[8] In the literature, sometimes also referred to as *emas suasa*. The etymology of the Malay term *suasa* has been debated. Gonda suggested that Malay *suasa* is from Sanskrit *suvāsas* 'well-dressed, decked out' (of a woman, a cow, a town). Van Ronkel (1902:109, in Gonda 1952:137) derived Malay *suasa* instead from Tamil *śoguśā* (defined as 'pinchbeck'), but while the semantics fits better, the phonology does not. In any case, etymological speculations must take into account that copper-gold alloy is a fairly recent introduction into the Malay world.

Bona fide ELECTRUM (*elektrum, lakur emas dan perak*) contains no copper, rather it is a naturally occurring alloy of approximately two-thirds gold and one-third silver. Electrum was known to the ancients, who made coins out of it, including the 11.3 ounce shekel.[9]

5 Forging

Let us now resume our journey through history. As noted, by 2800 BC people in the Caucuses and the Middle East had the technology to smelt copper, tin and zinc. Iron, though, has a melting point another 800° higher than copper, beyond the reach of simple smelting furnaces. How could iron be obtained?

It turns out that iron couldn't be directly extracted (smelted) like other metals. But as the Hittites discovered around 1500 BC, you could heat IRON ORE (*bijih besi*) in a furnace to a point where 'blooms' of iron globules (RAW IRON or PIG IRON, Indonesian *besi gubal, besi kasar yg belum dikerjakan*) appeared in a mix of sludgy impurities. Then—even though the iron never 'melted'—if you kept heating and beating it, you could get the iron globules to fuse together as the waste rock was eventually driven out. The result was WROUGHT IRON (*besi tempa*). More will be said about wrought iron below.

In the early United States, IRON FORGES were located near streams or rivers, since the power of running water was used to operate the BELLOWS (*pengembus*), since a blast of air was needed to raise the temperature of the CHARCOAL (*arang*) sufficiently. In addition, running water was also used to operate TILT HAMMERS or TRIP HAMMERS which mechanically pounded the rock. Those forges must have been hot, noisy places!

As seen above, some metals are smelted: an ore is heated and the molten metal flows out. The place where this is done is called a SMELTERY (*tempat meleburkan bijih*) and the person working there a SMELTER (*tukang pelebur*). Iron, however, was extracted by a process of FORGING (heating and hammering) (*menempa, memanaskan dan memukul-mukul besi kasar sehingga kotoran dikeluarkan menjadi besi betul*). The place where this was done is called a FORGE, and the people working there FORGE WORKERS.[10] In § 9 we return to the terms 'forge' and *menempa*, but used in a slightly different sense.

6 Wrought iron, steel, and cast iron

In the early years after its discovery, however, iron remained somewhat of a novelty metal: it was softer than bronze, and rusted easily. It wasn't until four hundred years after iron

---

[9] The Hebrew word חשמל *ḥašəmal*, which occurs three times in the Old Testament (Ezekiel 1:4, 1:27 and 8:2), may have referred to this metal, but scholarly opinion is divided between electrum, amber, or perhaps some other "precious stone of great brilliancy and color" (Allen 1994:26).

[10] This is not to be confused with the process of producing imitation money, which is called FORGERY, done on a PRINTING PRESS, and the people working there called FORGERS. ☺

was first forged that people discovered the process of packing iron bars with charcoal in clay jars and baking it for days. The result was a much harder and useful iron-carbon alloy, or what today we would call steel. The process of infusing iron with carbon is called cementation (after the compound iron carbide, or cementite, Fe_3C).

Around 500 BC the Chinese built the first furnace which was capable of producing molten iron, which could then be poured into molds—the world's first cast iron. It was a further thousand years before this technology reached Europe, and another thousand years still before the practice of casting iron became commonplace.

7 Grades of steel

Apart from when the chemical element iron (Fe) is intended, today when we speak of IRON (*besi*) we pretty much mean 'steel,' since iron without carbon is rarely used for commercial purposes. Nonetheless, the term 'iron' persists in a number of collocations, and can often be used synonymously with 'steel.'

Steel is graded based on its carbon content. In general, as the percentage of carbon in steel is increased strength also increases, but ductility and toughness decrease. At the high end of the spectrum is cast iron, which has a (relatively) low melting point and excellent pourability, but is too brittle to be further worked.

- ingot iron = has the lowest possible content of carbon, used largely for sheeting
- extra-soft (or dead-soft) steel = .08% to .18% carbon, tough and ductile
- structural grade (or mild) steel = .15% to .25% carbon, strength and easy machinability
- medium grade steel = .25% to .35% carbon, hard and strong yet can be forged
- medium-hard steel = .35% to .65% carbon (locomotives, car axles, railroad rails)
- hard steel = .65% to .85% carbon (steel wheels, woodcutting tools)
- spring grade steel = .85% to 1.05%
- carbon tool steel = 1.05% to 1.20%
- cast iron = 2% to 6% carbon; can be filed and trimmed, but is not further worked

Of course, this doesn't even begin to cover all the alloy steels (iron plus carbon plus some other element, such as nickel, chromium or manganese) which have been developed in the modern era. The possibilities are practically endless, though for economic reasons steel manufacturers prefer to limit their production to certain standards. The American Iron and Steel Institute lists well over a hundred such standards.

Where does wrought iron fit into the mix? Before the mid-nineteenth century, all steel (including cast iron) was produced via wrought iron, because the slag was needed to

remove (oxidize) alloyed impurities in the iron itself. To be sure, some improvements were made in the manufacture of wrought iron, for example mechanical rolling came to be used over hammering to squeeze out slag. But the entire process, including cementation, remained labor intensive. In 1856, however, Henry Bessemer in England discovered that alloyed impurities could be oxidized by blasting air through molten iron. Steel could be had directly and cheaply. Over the next seventy-five years, the old iron forges gave way to modern steel mills—and the world has never been the same since.

8 Corrugated iron roofing and more

Here are some terms for the form which iron and steel can take. These are compiled from Echols and Shadily (1982a, 1982b) and from *Kamus Besar* 3rd ed.

- MOLTEN IRON (*besi leburan*)
- IRON INGOTS (*besi bulat, besi batang, besi yg belum dibentuk*)
- IRON BARS (*besi lantak, besi lantakan, besi batang, batang besi*)
- IRON REINFORCEMENT RODS (*besi beton*)
- SHEET IRON (*besi lantai, besi lempeng*)
- GALVANIZED IRON SHEETING, usually corrugated and used for roofing (correctly *besi seng*, though throughout Indonesia colloquially called just *seng*)
- CORRUGATED IRON (*besi berombak, seng gelombang*)
- IRON PLATE (*besi papan*)
- HORSESHOE (*besi kuda*)
- CAST IRON, iron which has been cast while molten without being (further) hammered into shape (*besi cor, besi coran, besi tuang, besi cetak*)
- WROUGHT IRON, iron which has been worked by hammering (*besi tempa*)[11]

[11] The word ‘wrought’ literally means ‘worked’ (it comes from Middle English *wrogt*, metathesized form of *worgt*, past participle of *weorken*), but as an adjective has come to be applied only of metals, viz. metal which has been shaped by hammering or beating. Upon closer inspection it is possible to distinguish in English at least three different uses of the term ‘wrought iron’: (a) iron which has been forged, in this sense opposed to pig iron (see § 5); (b) a particular grade of iron which contains some slag and little carbon, in this sense opposed, for example, to ingot iron (a grade of iron which has even fewer impurities and a higher carbon content) (see § 7); the reason is that in the process of forging, iron is never brought to its melting point, and will naturally have different properties than iron which has been processed otherwise; and (c) iron which has been hammered into shape, in this sense opposed to cast iron (see § 9). Indonesian *besi tempa* clearly matches this third sense, but is probably to be extended to cover the first two senses as well.

9 Smithing

> *As when the smith … plunges the hissing blade,*
> *Deep in cold water, whence the strength of steel,*
> *So hissed his eye around the olive wood.*
>
> Homer, The Odyssey
> account of the blinding of Polyphemus

A SMITH is a person who makes or repairs metal objects, especially by shaping the metal while it is hot and soft. A BLACKSMITH (*tukang besi*, *pandai besi*) is a smith who works in iron (so called in English because 'black metal' was a former name for iron), compare for example a GOLDSMITH (*tukang emas*), someone who works in gold, TINSMITH (*tukang timah*), someone works in tin, and COPPERSMITH (*tukang tembaga*), someone who works in copper. The place where a blacksmith works is called a SMITHY or a BLACKSMITH'S SHOP (*bengkel pandai besi*, *tempat bejerka tukang besi*).[12] Figure 1 on the following page illustrates a blacksmith's shop in Tanah Toraja, South Sulawesi.

The heart of the smithy is the FORGE HEARTH (*dapur tempa*, also *tungku perapian*) which is fueled using CHARCOAL (*arang*). In this particular shop, the forge hearth is surrounded by a HEARTH WALL (*dinding dapur tempa*) made of refractory stone,[13] which in turn is enclosed by a FIRE WALL (*dinding api*). An ASH RAKE (*penggaruk abu*) is used to turn coals and rake up ashes.

In order to heat the charcoal sufficiently, indigenous metallurgy in the archipelago employs PISTON BELLOWS, two long cylinders placed vertically in parallel to each other, with the piston shafts protruding upwards. An operator pumps air by alternately pushing down the piston-shafts with his hands and feet, practically standing on them. When pumping, his movements are reminiscent of a frog treading water, hence the traditional name for a (pair of) piston bellows: *kodok-kodok* (from *kodok* 'frog'). More recently, however, the term *ubub* or *ububan* (< Javanese *ubub* 'blow on, fan') has been borrowed as the term for a blacksmith's bellows, while the term *kodok-kodok* has narrowed in meaning to refer to the pistons themselves.[14] The tube which funnels the air from the bellows to the forge hearth has a technical name in English, called the TUYÈRE (also spelled TWYER), in Indonesian simply *pipa*.

---

[12] Rarely, also called a smithery. More often, however, SMITHERY refers to the art or craft of a smith (*penempaan*, *tempaan*), rather than his place of work.

[13] Refractory stone is any stone which will withstand moderately high temperatures without fusing, cracking or disintigrating.

[14] Or any piston, for example, the pistons of an automobile combustion engine. The term *pengembus* can refer a blower of any kind, including a bellows.

A bellows
B tuyère
C forge hearth
D stone hearth wall
E fire wall
F anvil
G hammerer's pit
H quenching bamboo
I charcoal storage area

also pictured:

various hammers
ash rake
tongs
chisel
punch

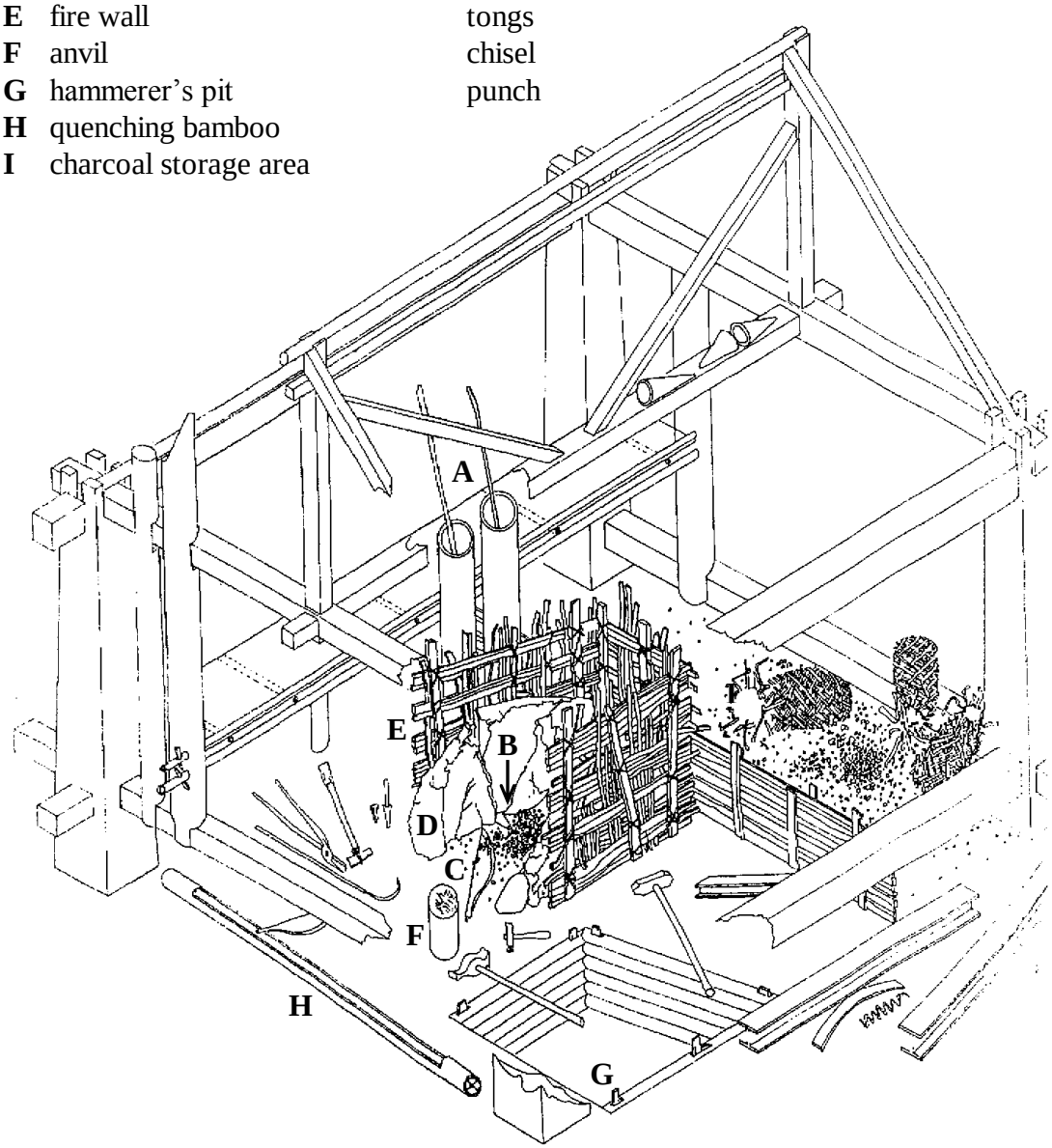

Figure 1. Blacksmith's shop in Tana Toraja, South Sulawesi
(from Zerner 1981:90, used by permission)

Usually a smith works with an apprentice, who may stand in a HAMMERER'S PIT (*lubang penukul*). Like forge workers, a smith and his apprentice also engage in the work of FORGING, that is, applying hammer blows to heated metal placed on an ANVIL (*landasan, paron*). However, unlike the raw hammering as at an iron forge, a smith applies directed hammering in order to form or shape the metal into a certain object (*menempa, menukul-nukul besi dsb untuk dibuat perkakas*). As hot iron is hammered, it gives off SPARKS (*pijar, percikan logam (besi dsb) yg menyala ketika ditempa*).[15] Generally, hammer blows are directed toward one of five basic forging operations:

- BENDING, often done with a JIG and specialized tools to make the process smoother and more uniform (*membengkokkan*)
- DRAWING, that is, stretching or flattening the iron
- UPSETTING, thickening the metal by reducing one dimension and increasing another
- SHRINKING, pounding a bulge or wavy portion flat to conform to a desired shape
- PUNCHING, making a depression or hole in the metal (*melubangi*)

On his TOOL RACK or TOOL TABLE (*rak perkakas, meja perkakas*) the smith will have various tools for working the metal, of which the most important are various HAMMERS (*berbagai palu tempa*)[16] and TONGS (*penjepit*). Other standard tools are CHISELS (*pahat*) including both HOT CHISELS (*pahat potong panas*) and COLD CHISELS (*pahat potong dingin*), PUNCHES (*pons, peranti untuk melubangi*), a VISE or CLAMP (*catok*) for holding the metal steady, and various other iron forming tools (*alat pembentuk besi*) such as SWAGES and FULLERS. A swage (also called a 'swagger,' 'hardy tool' or simply 'hardy') is a form into which metal is driven in order to shape it, while a fuller is a form which is itself driven into metal. Often a swage and a fuller are paired (e.g. concave swage with matching convex fuller) to create a die which can quickly bring metal into the desired shape.

At a blacksmith's shop there will also be a CHARCOAL STORAGE PLACE (*tempat penyimpaan arang*), and probably another area for SCRAP IRON (*limbah besi*)[17] such as rails, shock absorbers and automobile leaf springs which the smith will use in his work (*bahan untuk ditempa, bahan kerja tukang besi*).

Besides forging, described above, other tasks of a smith include:

---

[15] To give off such sparks is *berpijar-pijar*.

[16] A sledge hammer is called a *palu godam* or *palu besar*; a ball hammer is a *palu bulat*. A regular claw hammer (not used by blacksmiths) is a *palu genggam*.

[17] Likewise, scrap metal in general is *limbah logam*. These terms can also be used to refer to 'iron scraps,' 'metal scraps,' e.g. the small bits of metal which are chipped or cut off during the process of smithing.

- WELDING, joining two pieces of metal of the same or similar kind, producing a smooth, blended joint (*melas*, *mengelas*). The process of simply joining two molten ends together by hammering is called FORGE WELDING (*mengelas tangan*).[18]
- TEMPERING, hardening metal by heating and suddenly cooling, usually by dipping in water (*menyepuh*, *mengeraskan (besi, dsb) dng proses mencelukkan besi yg panas ke dalam air*).[19] For tempering, somewhere near the anvil the smith will have handy a QUENCHING TANK (*teng*, *tangki*) or perhaps a QUENCHING BAMBOO (*bambu yg berisi air untuk mencelupkan besi yg panas*).
- ANNEALING, heating metal and then cooling it, usually slowly, to allow 'stretched' crystals to melt and reform (prevents brittleness) (*menguatkan (logam, besi, dsb) dng proses memanasi, kemudian mendinginkan secara pelan-pelan*).

Some smiths also MELT metal (*meleburkan logam*) and CAST (*mengecor*, *mencor*, *mencetak*) it in a MOLD (*cetakan*). But as can be surmized from the discussion in § 5, this is not done in your typical blacksmith's shop because of the high melting point of iron. A place where iron or other molten metals are cast is called a FOUNDRY (*pengecoran*).

10 Pamor and pattern-welding

Dating back to at least the ninth century, kerises and other blades of local manufacture in Indonesia have been valued for a wave-like pattern of veins or nerves or 'flames' on their surface, which become particularly visible when a blade is well cleaned. In Javanese and Indonesian, these striated patterns are called *pamor* (from Sanskrit *mur* 'entwine, bind together'), and were considered an indication not only of the quality of a blade, but also of the blade's spiritual power. In English these wavy striations can also be called PAMOR, but this is a technical term restricted almost exclusively to the discussion of Southeast Asian blades, and so should always be further defined on our own entries.

Pamor is achieved by layering different metals and repeatedly hammering flat, folding, slicing and hammering again in a process called PATTERN-WELDING.[20] In Sulawesi the two

---

[18] Forge welding contrasts with modern day processes of welding in which an ACETYLENE TORCH (*las gas*) or an ELECTRIC ARC is used to apply or produce extreme heat at a precise point. This modern type of welding requires that the parent metals be melted. but does not involve hammering. Welding in turn contrasts with SOLDERING (*mematerikan*) in which a third metal—not either of the parent metals—is melted at a low tempurature and used to join the two metals, and BRAZING, the same as soldering except that the third metal has a high melting point (generally above 800° F).

[19] More generally, in English 'temper' means to bring to the proper texture, consistency, hardness, etc. by mixing something or treating something in some way. Thus one can also temper paints with oil, temper clay by moistening and kneading, etc. Indonesian *menyepuh*, on the other hand, can also refer to the process of plating or gilding, hence the descriptive qualification added here.

[20] To view the process of pattern welding, see the YouTube video "Titisan Empu Gandring" at http://www.youtube.com/watch?feature=endscreen&NR=1&v=IqsmDofV0Kc (accessed September 16, 2012).

metals that were layered were iron and nickelous iron (Zerner 1981:97), but according to tradition, on the idland of Jawa iron from meteorites was used for pattern welding. Kerises and swords with pamor are no ordinary blades, and—though at one time valued in warfare—are now probably only used ritually or found as heirlooms. Frankel (1963) considers the process of pattern-welding to have been a local innovation, and not borrowed from India or Persia.

11 Tin and pewter, lead, mercury, zinc and aluminum

> *All of them are like copper, tin, iron and lead*
> *in the smelting furnace.* Ezekiel 22:18

The expression 'like a cat on a hot tin roof' has come down to us from the nineteenth century, when roofs were actually made of TIN PLATE (*besi putih*, *besi sadur timah*), made from dipping iron sheets in molten tin. Today you are likely to see tin plate as a roofing material only on historic buildings. Because of relative production costs, almost all of the corrugated roofing material found throughout Indonesia today is galvanized (with a zinc coating). Similarly, TIN FOIL (*timah daun*) gave way to ALUMINUM FOIL (*kertas aluminium*) in the early twentieth century.

I am hard pressed to tell you what objects today you are likely to find in Indonesia which are made out of TIN (*timah* or *timah putih*, also *stanum* < Late Latin *stannum*). As a magnet test easily demonstrates, so-called tin cans are actually made out of tin plate (thus correctly: 'tinned cans'). Prior to the arrival of Europeans, the kingdom of Malacca was well known in Southeast Asia for its 'tin' coins, but this knowledge has almost certainly been forgotten today. I have also seen pre-World War II Dutch sources which describe peoples of Central Sulawesi as possessing 'tin' plates and shields, but these—as with the coins—may actually have been made of pewter. Almost every object today which is colloquially referred to as made of 'tin' is either pewter, aluminum, or steel, the last with or without a plating of tin.

Nonetheless, tin is one of the earliest metals known to man, and some have speculated that the English word 'tin' has pre-Indo-European roots. Blust (1982:287–288) reconstructs Proto-Malayo-Polynesian (PMP) *timaRaq 'tin'[21] as the source of Malay *timah*, thus supposing an almost equal antiquity of this word. See further below.

PEWTER (*tembaga putih*)[22] is an alloy of tin, usually over 95% tin with only small amounts of copper and other metals. Pewter was once popular for making plates, dishes, cups, spoons and other eating utensils, but in this use has given way to glass and ceramic vessels over the last few centuries. In olden times, pewter dishes which contained lead were a

[21] In a later article (Blust 1999), he suggests that the original reference of PAN *timeRaq as probably to lead.

[22] *Kamus Besar* identifies—probably incorrectly—*tembaga putih* as a tin-lead alloy.

hazard, as the lead would leach out in acidic environments.[23] Today (lead-free) pewter is used mainly for decorative pieces. On inspection, pewter is easily distinguished from tin by its relative hardness. Tin is so soft you can scratch it with your fingernail—not a very useful property if making plates or shields!

Besides tin, LEAD (*timah hitam*, also *timbel* < Javanese, *plumbum* < Latin) was the other soft metal known to the ancients, and perhaps today may be best recognized as the metal inside of lead-acid car batteries. To the Romans, lead was known as *plumbum nigrum*, 'black soft-metal' if you will, while tin was called *plumbum album*,'white soft-metal' or *plumbum candidum* 'bright soft-metal.' In Malay these metals were contrasted as *timah* 'tin' and *timah hitam* 'lead,' but probably through influence of European languages *timah putih* has entered Indonesian as a newer compound specifically referring to 'tin.'

MERCURY (*air raksa* < Sanskrit *rasa* 'mercury'; also *merkurium* < Latin *mercurium* 'Mercury') was, and sometimes still is, used ritually and as a folk medicine. It is also used by small-time miners in the amalgamation process of refining gold and silver because of its ability to dissolve these metals. Similarly, mercury has been used in attaching gold leaf (gilding) to copper objects. Mercury was known before 2000 BC in India and China.

ZINC (*timah sari, seng* < Dutch *zink* < Old German *zinke* 'pointed'), though commonly used in alloys, was never extracted for itself until around 1000 AD in India and China, and was unknown in the West (other than as an 'unrecognized' waste product found in melting ovens) until the sixteenth century. Zinc is seldom used in its pure form. However, I remember back when I was in junior high school I once got some old zinc canning jar lids from my grandmother (I used the zinc in a science experiment).

ALUMINUM (*aluminium* < Dutch *aluminium* < Latin *alumen*) is now used in making pots, pans and other cooking utensils and objects. In rural Sulawesi I have even seen a kind of *tukang* who goes around with a blow torch and some molds, and for a fee will melt down your broken or worn aluminum-ware and recast it into a new object. Despite being the third-most common element in the earth's crust, aluminum was not isolated as an element until 1827, and became widely available only after a commercially viable process for extracting it from its ore was discovered in 1886.

12 Silver, gold, and uncovering the history of Insular Southeast Asia

> *There is no tracing the connections of ancient nations but by language.* Samuel Johnson

It is supposed that Austronesians, who originate from the Asian mainland, first sailed to what is now Taiwan around 4000 BC. Shortly before 3000 BC, a subgroup of these settlers sailed to the Philippines, and from there across Indonesia, Melanesia and into the great Pacific basin. The concensus among archeologists is that knowledge of metallurgy

[23] In the West, this property of leaded pewter gave rise to the notion that tomatoes were poisonous.

was introduced into the Austronesian world from what is now northern Vietnam at a relatively late date (last few centuries BC); in fact it is thought that Indonesia never experienced a real 'Bronze Age,' since the people who introduced the technology to make bronze also introduced the knowledge of how to make iron and steel (Higham 1996; Bellwood 1997:255 ff.).

Given this late introduction, it is clear that the Austronesians who arrived in Taiwan and later in the Philippines could not have had words for 'copper,' 'bronze' or 'iron,' since these metals were unknown to them. But herein lies an opportunity. Since metal and metal technology spread after the Austronesian languages of the Philippines and Indonesia were largely 'in place,' investigating the terms associated with metallurgy can provide important clues to trade and other relationships during an age for which we otherwise have scanty information.

For example, consider two words for 'silver.' (The discussions in the remainder of this section are summarized from Mahdi 1994.) Across much of eastern Indonesia, the word for 'silver' has the shape *salaka* or something derived from this (e.g. Modole *holaʔa*). This word originates from Sanskrit *śalākā* 'chip, blade of straw' after the practice, common in Java and presumably elsewhere, of cutting off chips or 'leaves' of silver to use as money. Curiously, but not coincidentally, the distribution of *salaka*-forms matches that of another word, *bunga lawang* 'clove' (*Syzygium aromaticum* (L.) Merr. & Perry), which originated from Malay (in Malay the term literally meant 'nail flower').[24] This word shows up in eastern Central Maluku in the corrupted form *buga-lawan* or something derived from it, and, importantly, in Sanskrit texts prior to the first century BC, as

Figure 2. Trade route as indicated by *salaka* 'silver' and *bunga lawang* 'clove'

[24] In standard Indonesian, *bunga lawang* has since shifted to the meaning of 'star anise.'

lavaṅga. Together these words for ‘silver’ and ‘cloves’ suggest an ancient trade route which reached from the Spice Islands to India; see Figure 2.

Now consider a second word for ‘silver,’ which is widespread in languages of western Indonesia and the Philippines and which generally matches the Malay word *perak* (in Tagalog *pilak* ‘silver,’ in other Philippine languages also *pila* ‘money’), but which is only sporadically found in eastern Indonesia. This word is not of Sanskrit origin, but derives from Old Khmer *prak* ‘silver.’ The spread of this word into Indonesia (and its replacement of the presumed older Malay term *salaka*) is associated with Funan, a kingdom which was established in the first century AD on the Mekong Delta and which, at the height of its power in the third century AD, encompassed Cambodia, southern Vietnam, and even parts of Laos, Thailand and Burma.

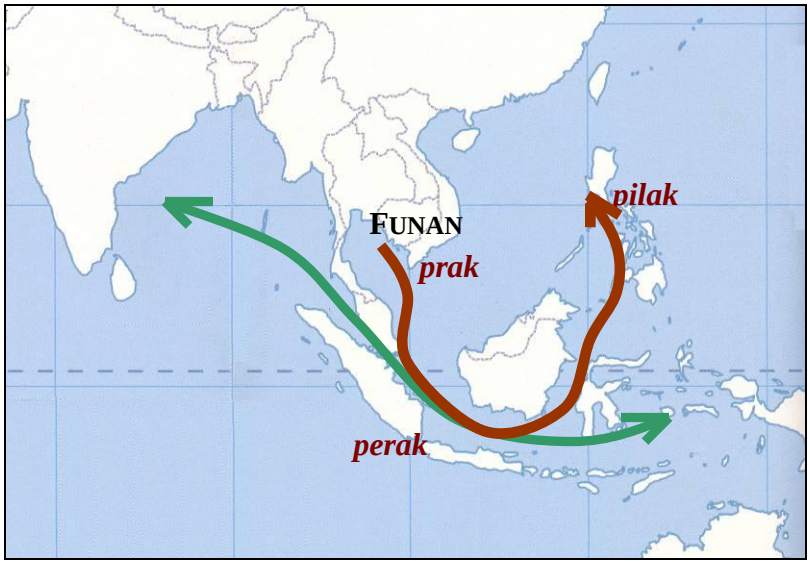

Figure 3. Secondary spread of Old Khmer *prak* ‘silver’

The presence of *perak*-derived forms in the Philippines, but not *salaka*-forms, has an important historical implication, namely that *the Malays did not venture into the Philippines prior to the rise of the Funan kingdom*. In fact one can even conclude that the rise of the Funan kingdom and their control over the South China Sea trading routes is precisely what led the Malays into the Philippines, as they sought an alternate route to China. See Figure 3. Even after the diminution of Funan’s power, the Malays maintained an entrepôt in Manila Bay, where the Malay language had a long and profound influence on Tagalog (Wolff 1976).

Similarly, the Old Khmer word *mās* ‘gold’ was also borrowed into Malay as *emas* around the same time (and for much the same reasons) that *perak* was borrowed. And like *perak*, *emas* presumably replaced an older term for gold. This older term for gold, however, was a ‘homegrown’ rather than a borrowed term. Robert Blust (1999) reconstructs it at the

level of Proto-Austronesian (PAN) as *bulaw-an 'gold.'[25] In an alternative interpretation, Waruno Mahdi considers the original meaning of this term to have been 'copper, brass'—a meaning attested by some reflexes in Kalimantan and Taiwan—but that it came to have the meaning of 'gold' in northern Sulawesi (a known gold-producing region from antiquity), whence the term was spread into the Philippines and to other parts of Indonesia (Mahdi 1994:182 ff.).[26]

A term for 'copper' or copper alloy which is of older vintage than even *tembaga* shows up in various languages of eastern Indonesia (but not Malay) as *niti*, *titi*, *riti*, *liti*, etc. (Mahdi 1994:181). The origin and history of this term is as yet unknown.

The history of terms for 'iron' is more complicated still, since many times over the name for a particular tool made of iron (such as axe, sword, sickle) has come to mean 'iron' (the metal) itself, and vice versa (Mahdi 1994:171–182). Nonetheless, the lesson for us lexicographers is clear. While we ourselves may never engage in debates regarding the prehistory of the Indonesian archipelago, our careful attention to detail regarding metal and metal working terms in our dictionaries will certainly aid those who do.

References and related works

Allen, Leslie C. 1994. *Ezekiel 1–19*. (World Biblical Commentary, 28.) Dallas: Word Books.

Bastin, John. 1971. Brass kettledrums in Sabah. *Bulletin of the School of Oriental and African Studies, University of London* 34:132–138.

Bellwood, Peter. 1997. *Prehistory of the Indo-Malaysian Archipelago*, revised edition. Honolulu: University of Hawi'i Press.

Bernett Kempers, A. J. 1988. *The kettledrums of Southeast Asia: A bronze age world and its aftermath*. (Modern Quaternary Research in Southeast Asia, 10.) Brookfield, VT: A. A. Balkema.

Blust, Robert. 1982. An overlooked feature of Malay historical phonology. *Bulletin of the School of Oriental and Asian Studies* 45:284–299.

Blust, Robert. 1992. Tumbaga in Southeast Asia and South America. *Anthropos* 87:443–457.

---

[25] It is generally agreed that gold was the first metal known to man, but its very early history is unclear. Gold was being mined and fashioned in what is now Eastern Europe as early as 4000 BC (National Mining Association 2004), and gold nuggets were probably collected long before that.

[26] Mahdi's argument also hinges on what was the original meaning of the stem *bulaw. Blust (In progress) reconstructs the meaning as 'golden colored,' but Mahdi (1994:183-184) associates it more with 'reflected light' (e.g. as light reflecting off of a film of oil or off of metal).

Blust, Robert. 1999. Linguistics versus archaeology: Early Austronesian terms for metals. *Archaeology and language*, part 3: *Artefacts, languages and texts* (One World Archaeology, 34), edited by Roger Blench and Matthew Spriggs, 127–143. London: Routledge.

Blust, Robert. In progress. Austronesian comparative dictionary. Computer files, Department of Linguistics, University of Hawai'i.

Bulbeck, F. David. 1996–1997. The bronze-iron age in South Sulawesi, Indonesia; Mortuary traditions, metallurgy and trade. *Ancient Chinese and Southeast Asian bronze age cultures: The proceedings of a conference held at the Edith and Joy London Foundation property, Kioloa, NSW, 8–12 February, 1988: Conference papers*, vol. 2, edited by F. David Bulbeck and Noel Barnard, 1007–1076. Taipei: Southern Materials Center.

Echols, John M. and Hassan Shadily. 1976. *Kamus Inggris – Indonesia*. Jakarta: PT Gramedia.

Echols, John M. and Hassan Shadily. 1989. *Kamus Indonesia – Inggris*, 3rd ed. Jakarta: PT Gramedia.

Frankel, J. P. 1963. The origin of Indonesian "pamor." *Technology and Culture* 4(1):14–21.

Gayle, Margot, David W. Look and John G. Waite. 1992. *Metals in America's historic buildings: Uses and preservation treatments*. Washington, DC: National Parks Service, U.S. Department of the Interior. Online. URL: http://www.google.com/books (accessed October 23, 2007).

Gascoigne, Bamber. From 2001, ongoing. History of metallurgy. *HistoryWorld*. Online. URL: http://www.historyworld.net/wrldhis/PlainTextHistories.asp?groupid=1267&HistoryID=ab16 (accessed Dececember 19, 2005).

Gonda, J. 1952. *Sanskrit in Indonesia*. Nagpur: International Academy of Indian Culture.

Heekeren, H. R. van. 1958. *The bronze-iron age of Indonesia*. (Verhandelingen van het Koninklijk Instituut voor Taal-, Land- en Volkenkunde, 22.) 's-Gravenhage: Nijhoff.

Higham, Charles. 1996. *The bronze age of Southeast Asia*. Cambridge: Cambridge University Press.

Hoekstra, H. J. 1919. Ijzer en animisme. *Indologenblad* 11:39–42.

Hoëvell, G. W. W. C. Baron van. 1908. Nog iets over messing-helmen, -schilden en -pantsers in het oostelijk deel van het O. I. archipel. *Internationales Archiv für Ethnographie* 18:95–99.

Holmström, John G. 1901. *Modern blacksmithing: Rational horse shoeing and wagon making*. New York: Henneberry Co. [Reprinted online. URL: http://www.lostcrafts.com/Blacksmith-Main.html (accessed November 7, 2007).]

Holmström, John G. 1913. *Modern blacksmithing: Rational horse shoeing and wagon making*. Chicago: Frederick J. Drake & Co. [Reprinted online. URL: http://www.usgennet.org/usa/topic/preservation/smithy/cover.htm (accessed November 7, 2007]

Kennedy, Raymond. 1934. Bark cloth in Indonesia. *Journal of the Polynesian Society* 43:229–243. [Reproduced online. URL: http://www.jps.auckland.ac.nz/index.php, (accessed June 21, 2010).]

Kruijt, Alb. C. 1901. Het ijzer in Midden-Celebes. *Bijdragen tot de Taal-, Land- en Volkenkunde van Nederlansch-Indië* 53:148–160.

Mahdi, Waruno. 1994. Some Austronesian maverick protoforms with culture-historical implications—I. *Oceanic Linguistics* 33:167–229.

Mahdi, Waruno. 1999. Linguistic and philological data towards a chronology of Austronesian activity in India and Sri Lanka. *Archeology and language IV: language change and cultural transformation*, edited by Roger Blench and Matthew Spriggs, 160–242. London: Routledge.

Marschall, Wolfgang. 1968. Metallurgie und frühe Besiedlungsgeschichte Indonesiens. *Beiträge zur Völkerkunde Südostasiens und Ozeaniens* (Ethnologica 4), edited by W. Fröhlich, 29–263. Koln: Brill.

Mathieu, James R. and Daniel A. Meyer. 1997. Comparing axe heads of stone, bronze, and steel: Studies in experimental archaeology. *Journal of Field Archaeology* 24:333–351.

National Mining Association. 2004. The history of gold. Online. URL: http://www.nma.org/pdf/gold/gold_history.pdf (accessed November 29, 2007).

Ronkel, Ph. S. van. 1902. Het Tamil-element in het Maleisch. *Tijdschrift voor Indische Taal-, Land- en Volkenkunde* 45:97–119.

Stevens, Alan M. and A. Ed. Schmidgall-Tellings. 2004. *A comprehensive Indonesian-English dictionary*. Athens: Ohio University Press.

Tim Penyusun Kamus Pusat Pembinaan dan Pengembangan Bahasa. 2001. *Kamus besar bahasa Indonesia*, 3rd edn. Jakarta: Balai Pustaka.

Wolff, John U. 1976. Malay borrowings in Tagalog. *Southeast Asian history and historiography: Essays presented to D. G. E. Hall*, edited by O. D. Cowan and O. W. Wolters, 345–367. Ithaca: Cornell University Press.

Zerner, Charles. 1981. Signs of the spirits, signature of the smith: Iron forging in Tana Toraja. *Indonesia* 31:89–112. Ithaca: Cornell University. [Reprinted online. URL: http://cip.cornell.edu/DPubS?service=UI&version=1.0&verb=Display&handle=seap.indo/1107015199 (accessed May 14, 2013).]