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Dagmar Wujastyk

University of Alberta, University of Vienna, dagmar.wujastyk@ualberta.ca

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Dagmar Wujastyk

Around the eleventh century CE, Sanskrit medical texts began to record profound changes in the methods used for drug manufacture. New substances, especially metallic and non-metallic minerals, were added to the ayurvedic pharmacopoeia or were given new prominence. More significantly, however, new ways of processing raw materials were introduced that were thought to make them fit for medical use. Most of the new, but also many of the traditional substances were now put through a series of complicated, multi-stage processes before they were used as components of compound medicines. In this article, I will use the example of recipes for iron-based medicines, which describe the processing of iron and other substances to trace the evolution of these changes and to query whether the changes in drug production flow from earlier developments, or whether they represent a more fundamental shift in the theory and practice of medicine. I also consider

whether the introduction of new substances and the new methods of drug production can be related to notions concerning the potency of substances and formulations.

Keywords: *Rasaśāstra*, Ayurveda, alchemy, *rāsayana*, tonics.

Introduction

It is October 2015, and I am in a garden shed in Dorset, perched somewhat uncomfortably on a low stool as I hold a piece of iron over a gas fire. Once it gets red hot, I will quench it in a decoction of *triphalā*, the three myrobalans. This is one of the steps in preparing an ayurvedic iron tonic.

My research team and I are here for a weekend with Andrew Mason, who will demonstrate various techniques of making ayurvedic vitalization tonics, called '*rasāyana*' in Sanskrit. Andrew has trained as an ayurvedic practitioner in the United Kingdom (UK) and has learned traditional techniques of making *rasāyana* tonics in Sri Lanka. This weekend is dedicated to us getting a hands-on experience of techniques that we otherwise only know from our work of translating Sanskrit medical and alchemical sources. We hope the direct experience of the substances and processes will enrich our historical and philological work, and are curious whether it might challenge some of the assumptions our translations and analyses of the textual materials are based on.

It is a weekend of shortcuts and make-dos: Andrew explains that most of the procedures need to be repeated many times and that we have only a fraction of the time needed to do everything properly. He will show us one cycle of procedures for several different tonics, so we can get a general idea of how they are done.

For our iron tonic, we start off with heavily-corroded pieces of iron which we coat with lemon juice and rock salt and then bring to a glow over a fire. Once they are red hot, we dip them in a decoction of the three myrobalans (*triphalā*) or in cow's urine (Figs. 1-3). This gradually breaks the iron down to flakes, which are then ground in a mortar for several hours. It is hard and slow work: grinding iron is not easy, the scraping sound is unpleasant, and nothing much seems to happen even after rubbing the flakes for an hour. Although we should continue to grind the flakes until they are a fine powder, we make do, and move on to the next step. This consists of mixing the iron powder with lemon juice and some pre-processed sulfur and shaping the mixture into little tabs. These are placed on an earthen plate (in our case, on a terracotta flowerpot saucer from a hardware store) and covered with sulfur. Another plate is placed on top and the container is sealed by luting it with mud-soaked strips of cloth. The contents are then baked for several hours in an earth pit (*puṭa*) with cow dung as fuel (Figs. 3-6). This is supposed to be repeated about thirty times; we have time for one round of baking. Each step normally spans several hours or even days, so Andrew fast forwards the process at several points by using materials he prepared earlier.



Figure 1. Preparing the iron tonic.

(Ayuryog, 2015)

It bears noting that all of this is not an experiment to recreate the past: Andrew is showing us what he learned in Sri Lanka, albeit translated to circumstances in the UK and tailored to our time constraints.¹ The past is, however, implied in our present actions. In Sri Lanka, Andrew's instructors' points of reference were selected Sanskrit medical and alchemical texts and their translations into Sinhalese on the one hand, and indigenous medical knowledge handed down through family lineages on the other. The place in which Andrew studied the making of these kinds of medicines was a small-scale production site that relied on simple techniques and basic instruments reminiscent of what is described in the Sanskrit medical texts: open fires, clay and metal pots, stone and metal mortars, and fire pits. The high-tech infrastructure and instruments of pharmaceutical production found in larger ayurvedic pharmaceutical factories were not available in this setting.

In the garden shed in the UK, we use a gas fire instead of an open fire for heating the iron strips, as well as safety gloves and glasses, none of which would have been available in the times of the early medical treatises. Our fire



Figure 2. Bringing the iron strip to a glow.

(Ayuryog, 2015)



Figure 3. Quenching the iron in cow's urine and triphalā decoction.

(Ayuryog, 2015)



Figure 4. Placing iron and sulfur on a clay plate.

(Ayuryog, 2015)



Figure 5. Sealing the clay plates.
(Ayuryog, 2015)



Figure 6. Fire pit for enclosed
roasting (*puṭapāka*).
(Ayuryog, 2015)

pit is perhaps closer to what was used in the past: we dig out a hole in the ground, cover the bottom with cowpats, place the earthen container on top, and cover it with more cowpats, which we then set on fire. Cowpats, still a staple fuel in India, are hard to get in the UK. Andrew collected cow dung from a somewhat amused neighboring farmer and made the pats himself.

The raw materials we are using perhaps constitute the biggest difference to what was used in the past. They are partly sourced from India and partly from the UK. The iron strips are scrap metal from a boat found on the beach; the

sulfur is pharmaceutical grade, extracted in the Frasch process, and bought from a chemical supplier in the UK. The myrobalan powder is imported from India, as are some of the salts.

After the weekend, we find that people try not to stand too close to us on our train journey home: we reek of cow's urine and sulfur. But apart from the stench, we also take home a sense of deeper understanding of the procedures involved in making *rasāyana* tonics. Despite all the shortcuts and alterations to the procedures, the practical engagement with the procedures has given us

a real sense what they entail in terms of time, effort, and skill. I am struck by how simple, but also how laborious and time-consuming, the methods of production are. This is partly due to the products Andrew chose for the weekend. Other materials would have necessitated more complicated apparatuses and greater care in submitting them to the various procedures. Generally, we are alerted to how much information is missing from the recipes in the ayurvedic works.² Andrew often explains the function of the processes, such as that coating the iron with an acidic substance will help break down the iron, or that the heating and quenching will make the iron brittle, so that it will become possible to grind it. He also describes how the end product should look and feel: a fine powder that will stick to the lines in the skin of the hand and float on water. None of this is explained in the ayurvedic works that I am familiar with. My colleague remarks on the circularity of the processes and the concomitant passing of time: Again, something that is not immediately apparent from the descriptions of iron tonic manufacture in the Sanskrit medical texts.³

We reflect on the differences between the early medical treatises' *rasāyana* formulations and those of the later ones. Techniques for making *rasāyana* tonics were developed over centuries: our oldest sources for them are the early Sanskrit medical works, the compendia of *Caraka*, and *Suśruta*, both of which roughly date to the early centuries CE.⁴ Their *rasāyana* recipes were carried forward to the newer medical works, each work adding new formulae, often introducing new materials.

The iron tonic we make under Andrew's instructions incorporates ways of making *rasāyana* formulations attested in both older and newer Sanskrit medical literature. Two elements of the procedures in particular diverge from what we know of procedures for making metallic medicines from early Sanskrit medical sources, namely the use of sulfur, and the roasting of the materials in an enclosed capsule of clay saucers in a fire pit. The early Sanskrit medical works did not include sulfur in their descriptions of making iron tonics or other *rasāyana* formulae. In general, sulfur was rarely mentioned in the early Sanskrit medical works' recipes, but it seems to have become a more common ingredient after the eleventh century. For example, sulfur was described as an ingredient of a copper tonic in the eleventh-century medical work *Cakradatta* and occurs frequently as a prominent ingredient in *rasāyana* preparations in the twelfth-century *Vaṅgasenasamhitā*.⁵ Similarly, the method of roasting substances by enclosing them in a sealed container of clay probably first occurs in the *Cakradatta*.

One of the differences between the older and newer *rasāyana* formulae is the increased use of metallic and non-metallic minerals, and especially of mercury, in later works. A further distinction lies in the introduction of more complicated procedures for making the medicines. From about the eleventh century, we find both an increased use of new materials, and new techniques of dealing with raw substances that reflect medicine's engagement with alchemy, and mark the emergence of iatrochemistry in both medical and alchemical literature.⁶

But how different were these new recipes and the techniques associated with them? How do they compare with, for example, recipes for metallic and non-metallic mineral-based medicines in the older works? Was the emerging trend towards iatrochemistry in medicine just a matter of iatrochemical formulae being used more widely or frequently, or was there a deeper change? In the following, I will trace some of the developments in pharmaceutical production methods and the concomitant changes in the understanding of raw and processed materials, using the production of iron-based tonics as described in the earliest and in later Sanskrit medical works as an example.

Both of the earliest Sanskrit medical treatises, the *Carakasamhitā* and the *Suśrutasamhitā*, describe the making of iron formulations. In the *Carakasamhitā*, the recipe for an iron tonic occurs in its chapter on vitalization tonics (*rasāyana*).⁷ The *Suśrutasamhitā* gives three somewhat similar recipes for iron medicines in its chapter on serious and advanced skin diseases (*mahākūṣṭha*), one of which will be discussed in detail here.⁸ Both treatises state that the described methods for working iron into a medicinal product can be applied to other metals as well. Several centuries later, a highly complex recipe for an iron tonic is described in the in the eleventh-century *Cakradatta*, a treatise on medicine composed by an author called Cakrapāṇidatta. As I hope to show, this recipe shows significant changes from the older recipes that exemplify the beginning of what might be called the iatrochemical turn in medicine. Finally, I will showcase a section dedicated to the processing of iron for medical purposes from the sixteenth-century medical treatise *Bhāvaprakāśa*, which represents a mature stage of iatrochemistry in Ayurveda.

The Carakasamhitā's Iron Tonic (*Carakasamhitā*, *Cikitsāsthāna* 1.3.15-23)

One should successively quench red hot leaves of 'sharp iron' that are four fingers long and of the thickness of a sesame seed in the juice of the three myrobalans, cow's urine and alkali prepared from

salt, zachum oil tree (*iṅgudi*) and also flame-of-the-forest.⁹ (15-16)

Having ascertained that they resemble collyrium, one should grind them into a fine powder. The powder is mixed with honey and the juice of the emblic myrobalan like an electuary and placed in a jar that has been greased with clarified butter. An experienced person should store it for a year in a barley grainery, giving it a good stir every month. (17-19ab)

After a year has passed, it is taken with honey and clarified butter every morning. Once it is digested, one who hopes for strength [should take] appropriate food. (19cd-20ab)

And the one who partakes of metallic formulations as described is not assailed by either injury or sickness, ageing or death; he will have the vigour of an elephant and always have acute senses. (20cd-21)

A man who takes this iron tonic for a year will become intelligent, famous, one who has perfected speech and who retains what he has heard and very wealthy. (22)

The application of both gold and silver through this method accomplishes the extension of lifespan and removes all disease. (23)¹⁰

One of the notable features of this recipe is its lack of detail in regard to the specifics of preparing it. To begin with, it seems to start in *medias res*, with the thin pieces of iron being quenched in liquids. The recipe does not describe the method of bringing the iron pieces to a glow. Also, while it specifies the size of the iron leaves (four fingers long, of the thickness of a sesame seed), no instructions are given on how to obtain metal leaves of that size and shape, leaving the question open as to whether the person making the medicine has done some preliminary metal work in preparation for the main procedures, or has purchased ready-made iron leaves. We do not know how iron was sourced by physicians in the times the early Sanskrit medical treatises were composed: the treatises give no description of mining or of buying metals from suppliers. However, we know that iron was a readily available material at the time, so that it seems very possible that a physician could simply have bought iron leaves in the needed size.¹¹

The recipe also does not give quantities for any of the ingredients.¹² Furthermore, while the word ‘successively’ (*kramaṇa*) implies that the iron leaves are dipped into each listed liquid separately, it is not quite clear whether the iron leaves should be reheated between dippings, or whether the successive dippings would be done all in one

go. The text does not explicitly prescribe repetitions of the actions of heating and quenching, though there is some indication that they may be repeated until a certain result has been achieved, namely that the iron leaves become similar in appearance to collyrium.

The recipe details that this collyrium-like product is ground to a powder, mixed with honey and the juice of the emblic myrobalan, and then stored for a year, after which the mixture is taken together with honey and clarified butter. The text does not elaborate on the potentially different functions of the ingredients. Is there a difference between the liquids used for quenching the heated iron leaves and the substances mixed with the iron powder, or those added for the intake of the medicine? Are the juice of the myrobalans, cow urine, or the various alkali understood as medicinally active components of the medicine which add to its therapeutic potency, or is their function merely to break down the metal? In the case of the myrobalans, at least, it seems quite likely that their juice is meant to add to the medicine’s efficacy, as the *Carakasamhitā* dedicates a big part of its *rasāyana* section to the health-, longevity-, and rejuvenation-promoting qualities of the myrobalans.¹³ However, no parallel information is present on cow urine or alkalis. Finally, what differentiates the honey and the juice of the emblic myrobalan that the iron powder is mixed with before being stored for a year from the honey and clarified butter that are added when the medicine is taken? The recipe provides no clarification of these issues.

We also do not learn anything about the dosage for this tonic beyond the time frame of a year for its continuous intake.¹⁴ While the outline of how to make the tonic and how to apply it is thus somewhat brief, the text is nevertheless assertive in attributing extensive effects to this and other metallic medicines, whose projected actions cover the whole range of vitalization tonic (*rasāyana*) effects: health, juvenescence, longevity, sensory and cognitive power, wealth, fame, and perfection of speech.¹⁵

A very similar recipe is found in the seventh-century *Aṣṭāṅgasamgraha*’s chapter on vitalization tonics (*Uttarasthāna* 49.53-54). This recipe simplifies the procedures by only prescribing the use of the juice of the emblic myrobalan for the quenching of the heated iron pieces, and also using it for mixing it with the iron powder before it is stored. Interestingly, the recipe gives some of the information missing in the *Carakasamhitā*, such as how often the procedure of heating and quenching is repeated (twenty one times); the amounts of iron (100 *pala*); that the immersion in the juice of the emblic myrobalan for several months serves to dissolve the iron leaves;¹⁶ and the dosage for the daily intake (a portion of about the size of the first

digit of the thumb). The recipe also gives more detailed instructions on the regimen for the ingestion of the tonic, which is preceded by cleansing procedures (purgation and emesis) and takes place in a special chamber.

Suśruta's Iron Tonic (*Suśrutasaṃhitā Cikitsāsthāna 10. 11*)

Now, in the following, I shall describe the preparation of iron.¹⁷

One should coat thin leaves of 'sharp iron' with the group of salts, bring them to a glow over a fire fueled by cowpats and then quench them with a decoction of the three myrobalans and the group (of timbers) beginning with sal tree (*śālasāra*) sixteen times.¹⁸ Then, they should be made red-hot on coals of catechu wood, and once cooled, ground to a fine powder and strained through a coarse cloth.

One should use an appropriate (*yathābalaṃ*) quantity mixed with clarified butter and honey. Once it has been digested, one should take food free of acid and salt as is suitable for the disease. In this way, after having taken one *tulā* (ca. four kilograms), one eradicates skin diseases (*kuṣṭha*), urinary diseases (*prameha*), obesity, swelling, anemia (*pāṇḍu*), insanity and falling disease and one lives for a hundred years. For each *tulā*, there is an increase of one hundred years (of lifespan). Hereby, the methods for preparing iron and for all metals have been explained.¹⁹

The *Suśrutasaṃhitā*'s recipe differs slightly from the *Carakasamhitā*'s and is a little shorter, but gives some of the detail missing in the *Carakasamhitā*, such as instructions on how to heat the iron strips (whose dimensions, however, it does not provide). There are no instructions on the quantities of the ingredients needed for the making of the medicine, and advice on the amounts a patient should take are somewhat vague ("an appropriate quantity"), though the effects of the medicine seem to be bound to the total amount taken over time. As the recipe occurs in the chapter on the disease group of *mahākuṣṭha*, i.e., serious diseases that present on the skin, the medicine's main indication is for this group of diseases. However, several other disease categories are also mentioned, and the medicine also is attributed with a characteristic typical of vitalization tonics, or *rasāyana*, namely the prolongation of life up to one hundred years and more.

Some of the plant materials used for quenching the heated iron are different from those mentioned in the *Carakasamhitā*. The *Suśrutasaṃhitā* concurs with the *Carakasamhitā* in its use of the juice of myrobalans for quenching the metal, but does not mention the alkalis.

Perhaps their function is replaced by the coating of the iron pieces with salt before they are heated on a fire. The *Suśrutasaṃhitā* also lists the Sal tree (*śālasāra*) group of timbers for the quenching process. This group is defined in *Suśrutasaṃhitā, Sūtrasthāna 38.9* as comprising twenty three different plants, which are indicated for *kuṣṭha*, and *meha* and *pāṇḍu* diseases, and fat (*medas*; or obesity): all conditions addressed by the *Suśrutasaṃhitā*'s iron medicine. Indeed, one of the recipes preceding its iron preparation against *kuṣṭha* is based on the *śālasāra* group of timbers (*Suśrutasaṃhitā, Cikitsāsthāna 9.10*). While not stated explicitly in the iron medicine recipe, this points to the function of the materials used for quenching as directly contributing to the medicine's potency and efficacy.

In contrast to the *Carakasamhitā*'s recipe, the *Suśrutasaṃhitā*'s recipe makes note of a repetition of procedures, prescribing that the heating and quenching of the iron should be repeated sixteen times. A final heating is concluded without a quenching in liquids and the iron is then powdered and passed through a cloth. Just as in the *Carakasamhitā*, the medicine is taken with honey and clarified butter, but without having been mixed with honey and the juice of the emblic myrobalan and stored for a year beforehand.

The *Cakradatta's* Iron Tonic (*Cakradatta 66. 34-125*)

The *Cakradatta's* recipe for 'immortality-essence iron (tonic)' (*amṛtasāralauha*) is a highly complex, multi-stage formulation. It is presented as deriving from Nāgārjuna's *Lauhaśāstra (Treatise on Metals)*, a work that is not available to us at present, other than through references to it in some medical and alchemical works.²⁰ The *Cakradatta's* passage is the most extensive reference to the *Lauhaśāstra*, but it is presented as a paraphrase rather than as a direct quotation of Nāgārjuna's work. The iron tonic recipe takes a central place in the *Cakradatta's* chapter on vitalization tonics (*rasāyana*): the author devotes ninety one of the chapter's altogether 201 verses to it. For brevity's sake, I will summarize the described procedures rather than translate the full recipe.

The recipe is structured into several stages and begins with a description of preliminary preparations and quantities of ingredients (verses 1–50). The section can be subdivided into the following parts:

1. attribution of the recipe to Nāgārjuna's *Treatise on Metals (Lauhaśāstra)* (34)
2. enumeration of the ingredients of iron, the three myrobalans (*triphalā*) and milk and their relative quantities as well as the allocation of

these quantities to the processes called ‘killing’ (*māraṇa*), ‘enclosed roasting’ (*puṭana*), ‘roasting in a pan’ (*sthālīpāka*), and ‘(final) roasting of iron’ (*lauhapāka*) (35–44)

3. enumeration of plants used for removing the defects of iron; the amount of clarified butter used during the final roasting of iron; and the quantities of the above-mentioned plants in relation to the quantity of iron (45–50).

The next section (verses 52–62) describes the processes associated with the ‘killing’ (*māraṇa*) of the iron, i.e., its calcination. This involves various ritual acts to begin with, such as setting up an altar to worship Śiva, lighting a fire and making oblations according to Vedic rules, and giving gifts to attending brahmins and the blacksmith (*karmakāra*, *lauhakāra*) (52–54). The ‘killing’ process proper begins with the purification of the iron through pasting it with a number of plant materials (55–56) and continues with its subsequent heating, liquifying, and quenching, after which it is ground into a powder (57–62).

The text then describes three methods for roasting (*pāka*) the iron, which seem to follow on from each other:

1. ‘Sun-roasting’ (*bhānupāka*), verses 63–64: For this, the iron is ground to a powder, washed with water, dried on a fire and then in the sun, and then ground in an iron mortar once more.
2. ‘Roasting in a pan’ (*sthālīpāka*), verses 65–66: This involves roasting the iron (powder?) in an open vessel with a decoction of the myrobalans until the moisture has evaporated and repeating the process with a series of plant juices or a mixture of them.
3. ‘Enclosed roasting’ (*puṭapāka*—referred to as *puṭana* earlier), verses 67–75. This entails the baking of ingredients in a sealed container that is placed in a fire pit. The method of enclosed roasting involves several repetitions, each of which is preceded by the preliminary maceration of iron powder with herbal liquids, the drying of the mixture through ‘roasting in a pan,’ and the admixture of nine plants with the iron before sealing the container for another round of roasting in the fire pit.

Verses 76–84 describe the first method for the final roasting of the iron (*lauhapāka*). This entails a further round of cooking the iron with the rest of the myrobalan decoction, clarified butter and milk in a pan made of iron, brass or copper and pasted with mud. The degree of roasting, i.e., how much liquid is allowed to evaporate, produces a different final product, which may be soft,

medium, or solid and appropriate for use against disorders of the humors bile (*pitta*), wind (*vāta*), or phlegm (*kapha*), respectively. Further herbal substances may be added at the late stage of cooking the iron.

Verses 85–88 describe the storage and application of the medicine and its side products. The final product is kept in an iron vessel or alternatively in a vessel lined with clarified butter or in a milk-pail; any excess clarified butter can be kept for medicinal purposes.

Verses 89–91 detail an alternative method for the final roasting of the iron (*lauhapāka*).²¹ This section describes the use of purified and powdered mica (*abhra*) as an alternative to the aforementioned materials used in the final roasting. The resulting preparation is stated to relieve thirst and hunger as well as promoting strength and alleviating problems associated with the humor bile (*pitta*). However, the use of mica necessitates its prior purification and ‘killing,’ which are described in verses 92–97. This section describes how to identify the right kind of mica for making medicine and how to cleanse and ‘kill’ it in multiple steps to ready it for use in the iron tonic: maceration with herbal substances, washing, pan-roasting, enclosed roasting, and a final heating. In the final heating process, powdered mica, now shaped into a ball, is enclosed in palm leaves and put on a fire and then finally quenched in milk and washed, rubbed, and strained. This results in a product that no longer shines or sparkles as unprocessed mica would.

The final section of the recipe (verses 98–123) gives instructions on the intake of *amṛtasāralauha* and the accompanying regimen. These include directions on worshipping Śiva; choosing an auspicious day for the intake of the medicine; appropriate initial dosage; the final preparation of the medicine accompanied by recitation of specific mantras; its intake together with appropriate drinks; the regimen and diet after intake of the medicine; more detailed instructions on dosage and length of intake; and a description of the effects of the tonic. The tonic is described as giving the consumer a stable and lustrous body that is free from disorders within three weeks. Finally, the recipe concludes with a summary in verses 124–125.

Some Comparisons Between the Older and Newer Recipes

The *Cakradatta*’s recipe contains a number of notable elements. In comparing this recipe with those of the *Carakasaṃhitā* and the *Suśrutasamhitā*, some differences are immediately obvious, the perhaps most striking being the length of the *Cakradatta*’s recipe, the increased number of steps the preparation of the tonic involves, and the amount of detail given for each step.

Generally speaking, given that the recipe in the *Cakradatta* is so extensive and elaborate, it is surprising that so little space is allocated to the effects of treatment. The text merely states:

Thus, one who partakes of this nectar attains a brightness and a durably stable body within three weeks. It furthermore removes all diseases.²²

By comparison the older treatises had more to say about the power and wide applications of their iron tonics, and it remains unclear why one should favor the *Cakradatta*'s complex iron medicine over older formulations.

In the *Cakradatta*, both the making of the medicine and its intake are preceded or accompanied by rituals, the recitation of mantras or worship of Śiva, features that are absent from the *Carakasamhitā*'s and *Suśrutasamhitā*'s iron tonic recipes described here. However, it should be mentioned that ritual and mantras (though not the worship of Śiva) are referred to in the early medical treatises in their chapters on vitalization tonics (*rasāyana*). For example, both the *Carakasamhitā* and the *Suśrutasamhitā* refer to ritual acts, such as offering oblations to a sacrificial fire and the recitation of hymns or mantras in the context of preparing or taking tonics.²³ Therefore, the ritual elements and the use of mantras do not constitute a change in how medicines and their intake was handled from the older to the newer medical works. However, the mention of Śiva worship does. This element reinforces the *Cakradatta*'s recipe's (in any case undisputed) provenance from an alchemical source: Much of Sanskrit alchemical literature presents Śiva as the main deity and representation of the Absolute.²⁴ A theory proposed by Sharma (1993) is worth noting here, namely that there existed a separate discipline called *lauhaśāstra* that was dedicated to the medicinal use of metals and especially iron and that was a precursor to, and competitor with, *rasaśāstra*, i.e., the alchemical discipline that focused in particular on the use of mercury. In the introduction to his translation of the *Cakradatta*'s recipe, Sharma (1993: 35) notes that

(t)he existence of *Lauhaśāstra* (science of metals, particularly iron) is proved by the extensive literature on this branch of technology, some of which is quoted in the commentaries. Nīścala Kara refers to 'Lauhaśāstravidah' (experts in *Lauhaśāstra*) in his commentary on the *Cakradatta* (CD).²⁵

Sureśvara, son of Bhadreśvara, mentions in his work entitled '*Lauhasarvasva*'²⁶ (Chowkhamba Vidya Bhavan, Varanasi, 1965) the names of his sources, such as Suśruta, Hārīta, Vyāḍi, Nāgārjuna, etc. (6,23). He adds one more point (*laghupākitā*—easy digestibility) in favour of *lauha* in addition to the

three others mentioned in favour of *rasa* (mercurial preparations) in the *Rasendrasārasaṅgraha* (1.4).²⁷ It clearly indicates that *Lauhaśāstra*, precursor of *Rasaśāstra*, was struggling hard to sustain its position in competition with the latter.

The authorities mentioned by Sureśvara here place *lauhaśāstra* into both a medical context through his reference to the ayurvedic authorities Suśruta and Hārīta, and into an alchemical one through the reference to the alchemical masters Vyāḍi and Nāgārjuna.²⁸ A clarification is needed here regarding the use of the term 'alchemy' for the Indian context. Often, Indian alchemy is used as a synonym for *rasaśāstra*, the body of knowledge concerned with the methods for producing and using mercurials and its associated literature.²⁹ This literature describes the making and use of mercurials in terms of transmuting substances, and ultimately transforming the consumer of the transmuted substances. The transmutation of the practitioner may span a spectrum of transformations from eradicating disease and endowing him with health; allowing him to attain extraordinary capabilities or superhuman powers (*siddhi*); to reaching of state of liberation, godhood, or oneness with the Absolute. The attainment of good health is a predominant concern in many *rasaśāstra* works (especially later ones), thus blurring the distinction between medicine and alchemy. In some cases, reference to Indian alchemy (here more in the sense of early or proto-chemistry) comprises Indian metallurgical knowledge more broadly, including technologies of metal-working not associated with specific philosophical underpinnings or soteriological aims or a particular body of literature. The discipline of metals (*lauhaśāstra*) referred to by Sharma seems to be dedicated to the medicinal use of metals rather than to any metaphysical aims or the manufacture of metal objects. Its association with alchemy is nevertheless present in one of the sources named by Sharma, the *Lauhasarvasva*.³⁰ This work at least seems to deal with the transmutation of materials through purification, 'killing,' and extraction of essences, albeit with a medical aim in mind.³¹ It also is quoted in a number of *rasaśāstra* texts, showing that although *lauhaśāstra* may have had a separate origin from *rasaśāstra*, the two disciplines integrated with each other to form a wider alchemical tradition.

I would suggest that the *Cakradatta* similarly stands between medicine and alchemy with its iron tonic recipe by using some production techniques developed in medical contexts, adding new procedures and then interpreting both old and new methods with an idiom first developed in alchemical milieus. Though none of the techniques described in the *Cakradatta* follow the heating

and quenching procedures outlined in the older treatises' recipes, the *Cakradatta's* procedure of 'roasting in a pan' (*sthālipāka*) has a precedent in another recipe for an iron tonic in the *Suśrutasaṃhitā*, which follows on from the one described above.³² This recipe describes boiling iron with various plant juices in a pan on a fire fueled by cow dung (*sthālyāṃ gomayāgninā vipacet*).³³ However, the *Cakradatta's* presentation of 'roasting in a pan' as a separate 'method' (*vidhi*) that is set within a wider context of a program of actions, formalizes the procedure in an unprecedented way.³⁴ The *Cakradatta* also introduces new or differently applied technical terms for the various metal-processing techniques, using a vocabulary that is typical for alchemical literature. For example, to my knowledge, the term 'killing' (*māraṇa*) for the calcination process is not used in earlier medical works, but is very common in alchemical literature and is frequently found in medical works that postdate the *Cakradatta*.³⁵

The term 'enclosed roasting' (*puṭapāka*) does occur in the *Suśrutasaṃhitā* in the context of eye treatments, but designates a method of obtaining juice from substances by wrapping them in leaves pasted with earth and cooking the bolus on charcoal to finally extract a juice.³⁶ In the *Cakradatta's* *puṭapāka*, the enclosure is no longer made of leaves but is a more solid vessel made out of clay or metal or other materials, and the result of the cooking is not a juice but a calcined material. Descriptions of *puṭapāka* that are similar to what the *Cakradatta* describes occur often in alchemical literature. Hellwig (2009: 303) notes that in alchemy, the goal of enclosed roasting in a pit is to accomplish the 'killing' of the roasted material, which entails the heating of substances in a pit whose size is determined, using a vessel made of specific materials, and a specified amount of particular fuel materials. These requirements are all fulfilled in the *Cakradatta*, which specifies:

1. the size of the pit: a cubic square measuring about eighteen inches (one *hasta*) in depth, length and breadth
2. by how much this is filled with fuel: by half at first, onto which the enclosing vessel is placed, after which the rest of the space is filled with more fuel
3. what fuel is used: cow dung, husk and wood
4. what materials the enclosing vessel can be: iron, or clay.

Although this is not explained in the *Cakradatta*, the size of the pit and the chosen fuels are key to a successful enclosed roasting, as they impact on what temperature is reached (and sustained) and the duration of the roasting

process. The vessel used for enclosing the materials shields them from direct contact with the fire.³⁷ The *Cakradatta* recommends repeating the *puṭapāka* process three or four times, each time including the rubbing of the iron with several plants and their juices. In alchemical literature, recommendations in regard to the repetition of enclosed roasting vary. For example, one passage in the *Rasaratnasamuccaya*, a relatively late (ca. sixteenth century) but also influential alchemical work, recommends ten to a hundred repetitions of enclosed roasting for making medicines, a hundred to a thousand repetitions for making vitalization tonics (*rasāyana*), and ten to five hundred repetitions for making medicines that enhance sexual power.³⁸ One can, however, also find smaller numbers of repetitions in the *Rasaratnasamuccaya's* descriptions of *puṭapāka* for iron specifically. For example, in its first method for calcining iron in chapter 5, verses 106-107, only four repetitions are prescribed.³⁹

The Concept of Removing Defects

The consistency of metals makes it necessary to process them in some way to make them ingestible: try biting on a piece of iron! However, beyond such practical considerations, the procedures described in the *Cakradatta* reflect a shift in understanding in regard to the nature of medicinal substances. I would like to draw particular attention to the idea that the admixture of certain plants to iron serves to remove the defects of iron. This concept is, for example, expressed in verses 46–47 with the mention that the three myrobalans, the three pungent substances and false black pepper serve for "the removal of the defects of black iron" (*kālāyasadoṣahr̥ti*); in verse 47, which notes that the plant *kāntakrāmaka*⁴⁰ on its own is able to remove the defects of iron (*kāntakrāmakaṃ ekaṃ niḥśeṣaṃ doṣaṃ apaharaty ayasaḥ*); and in verse 54, which describes the 'killing' process as something that will "free [the iron] from impurity" (*nirmalam kuryāt*). An alternative term often found in alchemical works and later medical works is 'purification' (*śodhana*). The *Cakradatta* also sometimes refers to materials as having been 'purified' (*śuddha*).⁴¹ Given that the associated procedures involve admixture of other substances, it is clear that they do not produce what we might today understand to be a pure, unadulterated product. Rather, the concept of freeing a substance from defects involves ridding a material of unwanted attributes. 'Purifying' a substance thus can be understood as a process of perfecting it for its intended use.⁴²

This idea of a material having a defect or blemish (*doṣa, mala*) that can, and indeed must, be removed through procedures involving other substances does not occur in the early Sanskrit medical works.⁴³ Similarly, the function

of a plant as something that can be used to remove blemishes or faults in other substances is also not found in the earlier works. However, it should be noted that the *Cakradatta*'s recipe provides no reasons for processing the materials. That is, we learn that the impurities or blemishes must be removed, but we are not told *why* the substances must be purified (see Gerke 2019 for a similar case in Sowa Rigpa). We can only infer an underlying concept of a substance's inherent qualities that include a judgment about the effects of contaminants or impurities. Perhaps it is self-evident that one would want to remove an impurity. However, in the case of the procedures for mica, dirt or blemishes are not mentioned, only that the final product will be lustreless. This again raises the question what the procedures are for. An approximately eleventh- or twelfth-century lexicon of *materia medica*, the *Dhanvantariyanighaṇṭu*⁴⁴ provides some information on the effects of using unpurified or improperly processed iron:

Iron that is unpurified and not well-processed will cause faults and diseases for sure. It very quickly spreads in the body and causes intense pain in the heart.⁴⁵

Similar statements are found in several alchemical works, e.g. the *Rasaratnākara* (1.9.1) and the *Rasaratnasamuccaya* (5.73). However, this kind of information did not make its way into the Sanskrit medical textbooks for a while. For example, the *Śārṅgadharasaṃhitā*, which dates to around the thirteenth or fourteenth century, devotes a full chapter to the processing of metals and minerals (2. 11, *dhātuśodhanamāraṇādhyāya*), and another one to the processing of mercury in particular (2. 12, *rasakalpanādhyāya*). However, even though this work provides much more information on the various methods for processing raw materials and uses many technical alchemical terms, we are still not given much by way of explanation what these processes are for. The author simply states at the beginning of the chapter on processing metals, that:

Gold, silver, brass, copper, lead, tin, and iron are known as the seven metals. The wise should purify them.⁴⁶

Iron-Processing in the *Bhāvaprakāśa* (*Pūrvakhaṇḍa* 2.3.89-105)

Finally, the sixteenth-century medical treatise *Bhāvaprakāśa* provides more information on why metals and some other substances need to be purified. This information is placed in a separate "section on the methods of purifying and killing metals, etc."⁴⁷ The *Bhāvaprakāśa*'s section on the processing of iron (verses 88-105) begins with a statement on the negative effects of using

unpurified iron, followed by directions on how to purify it and three different methods of 'killing' iron so that it becomes an ash (*bhasma*). It then outlines the properties of iron ash and the dose in which it would be applied. The section concludes with some dietary advice on which foods should be avoided during the period of intake. I would like to draw attention to the first part of the *Bhāvaprakāśa*'s exposition regarding its explanation about the effects of using unprocessed iron. It states:

It causes limping, serious skin diseases, and death. It effects heart disease and chest pain and kidney stones. And an unpurified iron preparation may also effect the outbreak of various diseases and cause heart palpitations.⁴⁸

Thus, we are finally given the reason why iron must be processed before use: purifying and killing iron frees it of its negative characteristics. What was effectively a poison is made fit for use as a medicine. This seems to reflect an assumption that iron in its 'raw', i.e., unprocessed state, is always unfit for use. A different passage (*Bhāvaprakāśa*, *Pūrvakhaṇḍa* 1.8.40) provides some information on the nature of iron's bad qualities (*doṣa*). It lists them as heaviness (*gurutā*), hardness (*dr̥ḍhatā*), corroding (*utkleḍa*), being dirty (*kaśmala*), causing burning (*dāhakāritā*), causing kidney stones (*aśmadoṣa*), and having a bad smell (*durgandha*). This shows the faults of iron to include both extraneous contaminants, such as dirt, and also intrinsic characteristics, such as heaviness or hardness that are canceled out through the purification and calcination.⁴⁹ During our workshop in Dorset, Andrew Mason suggested that the processing of iron and other metals was necessary to ensure their bioavailability, i.e., to make their absorption possible. I have, however, not been able to find direct reference to the digestibility of iron in the ayurvedic works.

One subject that is not raised at all in the ayurvedic sources is whether the procedures for cleansing and killing iron and other materials also have the function of heightening the material's power and its medical efficacy (other than through making it useable at all). Iron and other metals are portrayed as powerful medicinal substances once properly cleansed and calcined. But, notably, they do not seem to be attributed with a better efficacy or potency than herbal ingredients. Mercury alone is ascribed with a special potency and a wide application, but this only occurs in late ayurvedic literature.⁵⁰ An iatrochemical work from about the fifteenth or sixteenth century, the *Rasendrasārasaṃgraha*⁵¹ gives further reasons for the superiority of mercurials:

[Medicine based on] mercury is better than herbal medicines because it requires small doses in its

application, it does not cause loss of appetite and restores health quickly. Herbal medicine is prescribed by doctors in curable cases, but in incurable cases, mercurial medicine is given. It is therefore considered the best.⁵²

However, iron, and metallic medicines in general, were credited with a different characteristic that recommends their use: a prolonged shelf-life. The new kinds of metallic medicines were thought to be more or less imperishable. This characteristic is first pointed out in the *Śārīṅgadharasamhitā*, which states that a herbal substance loses its qualities (*guṇahīna*) after one year; a powder will lose its potency (*hīnavīryatva*) after two months from the day of preparation; pills and electuaries become defective (*hīna*) after about a year; medicated oils and butters after four months; and medicines prepared through a light heating process lose their potency (*nivīrya*) after a year. By contrast fermented preparations, metallic preparations, and mercurials retain their qualities (*guṇa*) forever.⁵³ Thus, metallic mineral medicines (with the exception of mercurials) were not considered to have a stronger potency than the classical, non-metallic formulations, but to have a longer-lasting potency. Whether the older metallic medicines were also considered to have the same long-lasting potency as the newer metallic formulations, or whether the new extended processing procedures were thought to be instrumental in producing the longer shelf-life of metallic medicines, cannot be extrapolated from the passage in the *Śārīṅgadharasamhitā*.

Conclusion

To recapitulate, even the oldest Sanskrit medical texts describe procedures for making mineral medicines that partly lay the grounds for later developments in the making of similar medicines. There are, however, significant differences between the older and newer procedures. The recipes from works from the eleventh century introduce not only new materials, but also new concepts to the making of medicines, showing engagement with alchemical methods of drug production.

These newer methods of drug production differ from the older ones in several ways:

1. an increased use of metallic and non-metallic minerals
2. the development of more complex procedures and new techniques for processing metallic and non-metallic minerals
3. the use of herbal and mineral substances and animal products (milk, urine) to cleanse or otherwise

alter substances (especially metallic and non-metallic minerals) to make them fit for medical use.

More significantly, these changes are underpinned with new concepts regarding the nature and functioning of substances. One of the marked differences between the older methods of drug production and the newer ones is the concept that some materials in their 'raw' state cannot be used for medical purposes, but need to be purified and 'killed' first. This idea is not expressed or even alluded to in the early medical treatises. Similarly, the idea that herbs and minerals may have not only a medicinal function but also can be used to change and optimize the properties of other substances, i.e., that they can be used as a kind of medicine for other materials, is found only in the newer works. The eleventh-century *Cakradatta* represents a kind of intermediate stage in the development of these concepts in that it prescribes the removal of impurities in metallic and non-metallic minerals, but does not define what the impurities are and also does not explain why their removal is necessary. The sixteenth-century *Bhāvaprakāśa* represents a more developed argument for the necessity of the purification and calcination procedures, explaining both the nature of the materials' impurities or bad qualities and their effects. It is also clearer in explaining the function of herbal and other substances in treating minerals etc., to make them fit for medical use. The greatest difference between the older and the newer descriptions of making metallic medicines does not lie so much in the multiplication and complexity of procedures, but in the meaning attached to the procedures and the reinterpretation of the characteristics of materials.

Notably, the new methods of drug production are not explicitly linked to a heightened potency of drugs: with the exception of mercurials, the new mineral medicines do not seem to be attributed with a greater potency or efficacy than the older mineral and herbal medicines. However, one characteristic that contrasts the new mineral medicines from older herbal ones (and possibly from the older mineral ones, though that is not clear) is their extended shelf-life, as noted in the *Śārīṅgadharasamhitā*. The latter states the power of medical substances wanes after a certain period, but the potency of metallic formulations remains unaffected by the passing of time. Only mercurials were specifically credited with both greater efficacy and potency than herbal and, by inference, other mineral medicines. But even this is only explicitly stated in some of the late medical and iatrochemical works, such as the *Rasendrasārasaṅgraha* and the *Bhāvaprakāśa*.

Dagmar Wujastyk is Associate Professor in History and Classics and Religious Studies at the University of Alberta and Principal Investigator of the ERC-starting grant research project AyurYog (ayuryog.org) at the University of Vienna. Her research focuses on the connected histories of classical Indian medicine (Ayurveda), alchemy and iatrochemistry (*rasaśāstra*), and yoga. Her publications include *Modern and Global Ayurveda: Pluralism and Paradigms* (SUNY Press) and *Well-Mannered Medicine: Medical Ethics and Etiquette in the Sanskrit Medical Classics* (OUP NY).

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Indian alchemy (*rasaśāstra*) and the new medical recipes and techniques associated with it. Regarding the dating of the emergence of Indian iatrochemistry to the eleventh century, it should be noted that an earlier medical work, the ninth-century *Kalyāṇakāraka* by Ugrāditya, already displays advanced knowledge of mercury-processing procedures and uses specialist technical vocabulary to describe them that shows the author's familiarity with alchemical thought. However, the placement of the *Kalyāṇakāraka*'s chapter on mercury-processing at the end of the work and especially the fact that the work contains very few recipes with mercury in the preceding chapters may point to the chapter being added at a later time. The question of the dating of this part of the *Kalyāṇakāraka* deserves more study. Because of the uncertainty of its dating, I work with the assumption here that the increased use of iatrochemical methods more or less starts with the eleventh-century *Cakradatta*.

Endnotes

1. This contrasts our workshop with the experiments conducted by Lawrence Principe and his colleagues, described in a special issue of *Ambix* (Vol. 62, no. 2), in which the authors reconstruct various procedures from various alchemical literatures. See in particular Fors, Principe and Sibum (2016: 85-92) on experiment as a tool for historians of science.
2. Omissions in recipes found in ayurvedic literature may point to a parallel oral transmission of medical knowledge. For information on how omissions in Sanskrit medical texts are dealt with in modern ayurvedic education and practice, see the studies by Roṣu (1982, 1984). See Gerke 2019 for a similar case in Tibetan medical texts.
3. See also Christèle Barois' blog post on this subject at <<http://ayuryog.org/blog/philology-through-experiment>> (accessed on 08 May 2019).
4. On the dating of Caraka's compendium (*Carakasamhitā*) and its complicated transmission history, see Meulenbeld (1999-2002: IA, 115) and Maas (2010). For Suśruta's compendium (*Suśrutasaṃhitā*), see Meulenbeld (1999-2002: IA, 342-344).
5. Recipes in the early medical works that mention sulfur include *Carakasamhitā*, *Cikitsāsthāna* 7.73, *Aṣṭāṅgahrdayasaṃhitā* 4.19.24, and 4.22.19, *Aṣṭāṅgasamgraha*, *Cikitsāsthāna* 21.70.
6. The term 'iatrochemistry' describes the use of alchemical procedures in the making of medicines. The term derives from European understandings of alchemy and is in particular associated with the medical applications of alchemical concepts and procedures developed by the Swiss alchemist Paracelsus in the sixteenth century. Here, I apply the term to the context of

7. *Carakasamhitā*, *Cikitsāsthāna* 1.3.15-23.

8. The ayurvedic disease category of *kuṣṭha*, and more specifically of *mahākuṣṭha* is today often interpreted as leprosy. By the modern biomedical definition, leprosy is an infection by the bacterium *Mycobacterium leprae* or *Mycobacterium lepromatosis*. Given that microorganisms as causative factors for diseases were not known until the nineteenth century and that *M. leprae* was only identified in 1873 by the Norwegian physician Gerhard Armauer Hansen, the correlation of *kuṣṭha* with leprosy is rather uncertain, though there is certainly an overlap in symptoms. In any case, even in ayurvedic sources, it is evident that the category of *kuṣṭha* has somewhat porous boundaries. The *Carakasamhitā* states in *Nidānasthāna* 5.4 that there are seven, eighteen, or indeed innumerable kinds of *kuṣṭha*. See Emmerick (1984: 97).

9. The identification of 'sharp iron,' rendered from *tikṣṇa* (sharp) and *ayas* (iron) is uncertain. Later medical and alchemical works differentiate between different types of iron (*ayas*, *loha*), called *kānta*, *tikṣṇa* and *muṇḍa*, each of which has different medicinal and other properties. See Hellwig (2009: 127-128). However, the *Carakasamhitā* does not provide any classification of types of iron. The *Suśrutasaṃhitā*'s iron medicine recipes in *Cikitsāsthāna* 10.11 and 10.12 use the terms 'sharp iron' (*tikṣṇaloha*), and 'iron' (*ayas*), respectively. *Ṇṅguḍī* is identified as *Balanites roxburghii* Planch. / *B. aegyptiaca* (L.) Delile / *B. Indica* Tiegh. by Nadkarni (1976: vol.1, 166).

10. *triphalāyā rase mūtre gavāṃ kṣāre ca lāvāṇe / krameṇa ceṅṅudikṣāre kiṃśukakṣāra eva ca //* (15.2) *tikṣṇāyāsasya pattrāṇi vahnivarnāṇi sādhatay / caturāṅguladīrghāṇi tilotsedhatanūni ca //* (16) *jñātvā tānyaṅjanābhāni sūkṣmacūrṇāni kārayet / tāni cūrṇāni madhunā rasenāmalakasya ca //* (17) *yuktāni lehavatkumbhe sthitāni ghṛtabhāvite /*

saṃvatsaram nidheyāni yavapalle tathaiva ca // (18)
dadyādāloḍanam māse sarvatrāloḍayan budhaḥ /
saṃvatsarātyaye tasya prayogo madhusarpiṣā // (19)
prātaḥ prātarbalāpekṣī sātmyaṃ jīrṇe ca bhojanam /
eṣa eva ca lauhānāṃ prayogaḥ saṃprakīrtitaḥ // (20)
nābhīghātairna cātankairjarayā na ca mṛtyunā /
sa dhṛṣyaḥ syādgajaprāṇaḥ sadā cātibalendriyaḥ // (21)
dhīmān yaśasvī vāksiddhaḥ śrutadhārī mahādhanah /
bhavetsamāṃ prayuñjāno naro lauharasāyanam //
(22) anenaiva vidhānena hemnaśca rajatasya ca /
āyuhprakarṣakṛtsiddhaḥ prayogaḥ sarvaroganut // (23)
 All translations my own, unless marked otherwise.

11. See, for example, Bhardwaj (1979: 143-162) on iron metallurgy in ancient India.
12. This contrasts this recipe with the other recipes in the chapter, which all give quantities for their ingredients.
13. See *Carakasamhitā, Cikitsāsthāna* 1.1-4.
14. The absence of dosage is not peculiar to the metallic formulation. Most of the recipes in the *Carakasamhitā*'s *rasāyana* section contain information on the quantities needed for making a medicine and the period of time in which the preparation should be consumed, but do not specify daily amounts.
15. On the typical functions of *rasāyana* medicines, see Wujastyk (2017).
16. The text states: "Thus, the iron leaves become liquid/absorbed after a year"—*evaṃ tāni lohapatrāṇi saṃvatsarāt dravibhavanti*.
17. The term used is *ayas*, which can mean iron, or metals.
18. This group of timbers is listed in *Suśrutasaṃhitā, Sūtrasthāna* 38.9 and comprises twenty-three different plants.
19. *ata ūrdhvam ayaskṛtīr vakṣyāmaḥ tikṣṇalohapatrāṇi tanūni lavaṇavargapradigdhāni gomayāgniprataptāni triphalāsālasārādikaṣāyeṇa nirvāpayet ṣoḍaśavārān tataḥ khadirāṅgārataptāny upaśāntatāpāni sūkṣmacūrṇāni kārayed ghanatāntavaparisrāvitāni tato yathābalaṃ mātrāṃ sarpirmadhubhyāṃ saṃsṛjyopayujjīta jīrṇe yathāvyādhyanamalavaṇamāhāraṃ kurvīta evaṃ tulām upayujya kuṣṭhamehamedaḥśvayathupāṅḍurogonmādāpasmārān apahatya varṣāsatam jīvati tulāyāṃ tulāyāṃ varṣāsatam utkarṣa etena sarvalauheṣv ayaskṛtayo vyākhyātāḥ // (11.1).*
20. References to a *Lauhaśāstra* are found in *Cakradatta* 69, 34; *Vaṅgasenasamhitā, Rasāyanādihikāra* 474, and *Rasendracintāmani* chapter 9, 76; see Meulenbeld (1999-2002: IIB, 703, note 177). The *Rasaratnasamuccaya* (chapter 5, verse 98-99), while not naming either the *Lauhaśāstra*, nor the *Cakradatta*, makes reference to parts of the mantra in *Cakradatta* 66.103.

21. That this procedure is an alternative to the first *lauhapāka* is expressed through the use of the word 'or' (*athavā*) in verse 89.

22. *Cakradatta* 66.123. *evaṃ tad amṛtam aśnan kāntiṃ labhate cirasthīram deham / saptāhatrayamātrāt sarvarujo hanti kiṃ bahunā.*

23. See, for example, *Suśrutasaṃhitā, Cikitsāsthāna* 27.8, which describes oblations to a sacrificial fire and hymns to accompany the intake of a false black pepper (*viḍaṅga*) tonic. Or *Suśrutasaṃhitā, Cikitsāsthāna* 28.4, 5, and 7, which describe sanctifying tonics with oblations to a sacrificial fire before taking them. *Carakasamhitā, Cikitsāsthāna* 1.23 prescribes the worship of gods before the patient enters the therapy hut. In regard to the use of mantras, reference is found, for example, in *Suśrutasaṃhitā, Cikitsāsthāna* 28.25, which states that the *Gāyatri* mantra should be spoken during the making of the formulations; and *Cikitsāsthāna* 30.27, which prescribes the incantation of a mantra during the harvest of divine herbs. Mantras also occur in *Suśrutasaṃhitā, Cikitsāsthāna* 28.25, *Aṣṭāṅgahṛdayasaṃhitā, Uttaraśthāna* 39.89 and *Aṣṭāṅgasamgraha, Uttaraśthāna* 49.83 in the context of taking an oil against serious skin diseases (*kuṣṭha*); and in *Aṣṭāṅgasamgraha, Uttaraśthāna* 49. 262-263 in the context of taking a medicine against diseases caused by the humors wind and phlegm. Mantras are, however, not mentioned in the *rasāyana* chapter of the *Carakasamhitā*.

24. On the prominence of Śaiva metaphysics in Sanskrit alchemical literature, see White (2011: 490-493).

25. Niścalakara's commentary on the *Cakradatta* probably dates to the middle of the twelfth century according to Meulenbeld (1999-2002: IIA, 105-109).

26. The *Lauhasarvasva* (or *Lohasarvasva*) by Sureśvara is a work on the medical use of metals dated to about the twelfth century, see Meulenbeld (1999-2002: IIA, 751-752).

27. The three reasons to favor mercurial preparations put forward in the *Rasendrasārasamgraha* (1.4-5.) are that they require small doses in their application, they do not cause loss of appetite and they restore health quickly. The *Rasendrasārasamgraha* may date to the fifteenth or sixteenth century or later. See Meulenbeld (1999-2002: IIA, 730).

28. On *Hārīta*, the author and compiler of the *Hārītasamhitā*, see Meulenbeld (1999-2002, IIA, 59-60). On *Vyāḍi* and *Nāgārjuna*, see White (1996: 125-126 and 66-77), respectively.

29. See, for example, the work of Ray (1956), White (1996), or Hellwig (2009).

30. The other works referred to by Sharma, such as the *Pātañjalalauhaśāstra* or *Amoghayogatantra* are not available at present; we know of them only through citations.

31. See Meulenbeld (1999-2002: IIA, 751-752) on the *Lohasarvasva*.

32. *Suśrutasaṃhitā, Cikitsāsthāna* 10.12 describes two further recipes for making iron tonics. The one referred to here is the first of the two.

33. In later alchemical literature, heating and quenching reappear as methods of processing iron. See, for example, *Rasaratnasamuccaya* (102-103). This work also shows some familiarity with the methods described in the *Cakradatta*, as evidenced by its reference to the mantra *om amṛtodbhavāya svāhā* and the associated procedures. See *Rasaratnasamuccaya* 5. 98-99 and *Cakradatta* 66.103.

34. The *Cakradatta* depicts several procedures or steps in making the medicine as a 'method.' This is marked in the text by the formulaic use of "iti ... vidhiḥ", "thus, the method for ...". These comprise 1) the specifications regarding the measurement and preparation of ingredients (*iti sādhyasādhanaparimāṇavidhiḥ*) 2) the purification of the iron through 'killing' (*iti lauhamāraṇavidhiḥ*), 3) the roasting of iron in the sun (*iti bhānupākavidhiḥ*), 4) the roasting in a pan (*iti sthālīpākavidhiḥ*), 5) the roasting in a pit (*iti puṭapākavidhiḥ*), 6) the final roasting of the iron (*iti lauhapākavidhiḥ*), 7) the processing of mica (*ityabhrakavidhiḥ*) and 8) the ingestion of the tonic and the associated regimen (*iti bhakṣaṇavidhiḥ*).

35. This term is also found in the *Kalyāṇakāraka*, but see footnote 6. The term 'killing' for calcination is used for one of several steps in the procedures (*saṃskāra*) for processing mercury described in Sanskrit alchemical literature. For a summary and discussion of these *saṃskāras* in Sanskrit alchemical literature, see White (1996: 266-269). 'Killing' is also one of the procedures applied to iron and to other metallic minerals. For a discussion of what the different kinds of procedures applied to metals and minerals tell us about the classification of materials in Sanskrit alchemical literature, see Hellwig (2014).

36. See *Suśrutasaṃhitā, Uttarantra* 18.33-38 on the method of *puṭapāka*.

37. Notably, this is information given in some alchemical texts. See Hellwig (2009: 303-304) for passages in alchemical texts in which the reasons for the size of the pit and the fuel used are stated.

38. See Hellwig (2009: 304-305).

39. See Dole (2008: 198) for the passage in question.

40. I have not been able to identify this plant.

41. See, for example, the recipe for a copper tonic in *Cakradatta* 66. 129-135, which follows the iron tonic recipe.

42. On the idea of purification as counteracting negative or undesired characteristics of the substances, see Dole and Paranjpe (2004: 84) and Wujastyk (2013: 37).

43. That is, other than through washing with water.

44. On the date of the *Dhanvantariyanighaṇṭu*, see Meulenbeld (1999-2002 IIA, 172-173).

45. *Dhanvantariyanighaṇṭu* 6.29. *doṣakāri gadakāri cāyasaṃ cedaśuddham asusaṃskṛtaṃ dhruvam/pāṭavaṃ na tanute śarīrāke dāruṇāṃ hr̥di rujaṃ karoti ca //*.

46. *Śārṅgadharasaṃhitā*, 2.11.1. *svarṇatārāratāmrāṇi nāgavaṅgau ca tikṣṇakam / dhātavaḥ sapta vijñeyās tatas tān śodhayed budhaḥ //*.

47. *dhātvādiśodhanamāraṇavidhiprakaraṇa*.

48. *Bhāvaprakāśa, Pūrvakhaṇḍa* 2.3.89. *khañjatvakuṣṭhāmayamṛtamṛtyukāri hṛdrogaśūlau kurute 'śmarīṇi ca / nānārujānāṃ ca tathā prakopaṃ kuryāc ca hr̥llāsam aśuddhalauham //*A similar list of effects, but adding impotence and intoxication is given in the *Bhāvaprakāśa*'s chapter on the properties of metals, *Bhāvaprakāśa, Pūrvakhaṇḍa* 1.8. 43-44.

49. See also Wujastyk (2013), which describes the *Bhāvaprakāśa*'s definition of the faults of mercury.

50. See the thirteenth- or fourteenth-century *Śārṅgadharasaṃhitā* 2. 12. 1, which describes mercury as a substance that conquers all diseases and confers strength; or the sixteenth-century *Bhāvaprakāśa, Pūrvakhaṇḍa* 1.8.10-15, which describes mercury as a panacea that can cure even incurable diseases.

51. See Meulenbeld (1999-2002, IIA, 730) on the date of the *Rasendrasārasaṃgraha*. This work might be later than the estimated fifteenth or sixteenth century.

52. *Rasendrasārasaṃgraha* 1.4-5. *alpamātropayogitvād arucer aprasaṅgataḥ/kṣīpram ārogyadāyitvād auśadhebhyo 'dhiko rasaḥ //sādhyeṣu bheṣajaṃ sarvamīritam tattvavedinā / asādhyeṣvapi dātavyo raso 'taḥ śreṣṭha ucyate//*.

53. See *Śārṅgadharasaṃhitā* 1.1.51-53: *guṇahīnaṃ bhaved varṣād ūrdhvaṃ tadrūpam auśadham/māsadvayāt tathā cūrṇaṃ hīnavīryatvam āpnuyāt //(51)// hīnatvaṃ guṭikālehu labhete vatsarāt param/hīnāḥ syur ghr̥tatailādyās caturmāsādhikāt tathā //(52)//ośadhyo laghupākāḥ syur nirvīryā vatsarāt param/purāṇāḥ syur guṇair yuktā āsavā dhātavo rasāḥ //(53)//*.

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