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MEDICINAL APPLICATIONS OF SWARNA-MAKSHIKA, RAUPYA-MAKSHIKA AND VIMALA

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Vimala

Abstract

Ayurveda is the ancient system of medicinal practice originated in India which includes different types of natural substances in its therapeutic uses, including various geological materials. The historical significance, medicinal applications, and modern controversies over various geological materials such as chapala, vimala, vaikranta, agnijara, kampillaka, and kankushtha hold controversy regarding their proper identification. Swarna-makshika, raupya-makshika, and vimala hold an appreciable place in ayurvedic texts, but their usage is accompanied by controversies and ongoing scientific research. Swarna-makshika, type of makshika, which is golden coloured copper, iron and sulphur containing mineral is used for curing various diseases. At the same time, raupya-makshika another type of makshika, which is considered to be synonymous to vimala in some ayurvedic texts and some ayurvedic texts mentions raupya-makshika and vimala as different entities. Current paper deals with this controversy and tries to solve it on the basis of geological and mineralogical parameters mentioned in ayurvedic texts and standard geology and mineralogy books. Understanding of these minerals and their therapeutic uses, benefits, and risks important for ensuring their safe and effective integration into contemporary healthcare system.

1. INTRODUCTION

Demand for safer and effective medicinal practice is increasing day by day and eagerness to develop Complimentary Alternative Medicine (CAM) is not historical or an urban-myth today (Patwardhan, 2010; Chopra and Doiphode, 2002). Various countries, especially developed countries have widely accepted CAM as an alternative or as complimentary medicine. In western countries CAM has been suggested to be used in treatment of cancer. Conventional medical system in India such as Ayurveda, Siddha, and Unani, which are as old as ~5000 years, are widely practiced in rural areas. Also, India has established a separate department in 1995 named as AYUSH (Ayurveda, Yoga, Unani, Siddha, Homeopathy) for promotion of Indian conventional medical system (Pandey et al. 2021). Ayurveda can be a good option regarding CAM but, most of the people are not keen to accept Ayurveda as CAM and have preconception regarding adoption of Ayurveda as alternative to mainstream medicinal system (Patwardhan, 2010; Chopra and Doiphode, 2002). Ayurveda focuses on the establishing co-ordination between human body constitution and function to nature, and hence this system will not end in the foreseeable future, but will develop further as per the demand of that time (Jaiswal and Williams, 2017). Ayurveda, meaning "Science of life," emphasizes more on promoting a healthy life rather than treating ailments born out of diseases (Mathapati et al. 2020; Sharma et al. 2007). According to Ayurveda, a human being is made up of three 'doshas', which are governing principles of physiology and psychology, and are considered the primary constitutional factors of the human body (Patwardhan and Puranik, 2012). These are 'Kapha', 'Pitta', and 'Vata'. This categorization is good indication of physiologic strengths and weaknesses, mental tendencies, and susceptibility to illness of various types. If the idea of doshas and prakriti is applied to other medical disciplines other than ayurveda, then it will make ayurveda more acceptable to modern medical systems (Hankey, 2005). Ayurveda is comprised of eight branches; namely, internal medicine, surgery, paediatrics, toxicology, psychiatry, ophthalmology, otorhinolaryngology, rejuvenation, and sexual health. Understanding Ayurveda's significance in contemporary times involves recognizing its holistic approach to well-being, which is rooted in ancient wisdom and tailored to modern contexts (Jaiswal and Williams, 2017).

The science of Ayurveda is believed to have originated around 5000 BCE, when the ancient scholars started employing medicinal substances and utensils characteristic of the system in the day-to-day life. By 1000 BCE, the Samkhya physiological system laid the foundation for Ayurveda, which then split into two branches: Dhanvantri Sampradaya, focusing on surgeries, and Brahma Sampradaya, emphasizing diagnosis, remedies, and other treatments. Ayurveda thrived in India until the 10th and 11th centuries, but faced setbacks during invasions in the northern regions from the 10th to 12th centuries. It experienced a revival in the 19th century and achieved a significant milestone with its inclusion in the Drug and Cosmetic Act in 1959 following India's independence (Tiwari et al. 2021). Today India is focusing on integrative health research in transdisciplinary, holistic approach to investigate the benefits of co-administering the modern system of medicine and traditional/complimentary/alternative medicinal practices to identify the comprehensive healthcare practices to an individual and the community (The Hindu, May 2023). Despite the prominence of synthetic drugs, natural products have retained their significance, although occasionally overshadowed. Natural products have long been central to traditional

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medicine, contrasting with synthetic drugs that primarily rely on isolated active compounds. Efforts in chemistry-based drug development have not always yielded expected outcomes, prompting a renewed interest in natural products combined with modern technology. This ongoing search underscores the enduring relevance and potential of natural remedies in contemporary healthcare (Yuan et al. 2016).

1.1. Background

Natural products which include materials related to plants, animals and minerals act as the base for treatment of human diseases (Patwardhan, 2010). Till date around one thousand single drug formulations and around eight thousand compound drug formulations have been identified. Ayurvedic pharmaceuticals are studied under two branches viz. Rasashastra (processing of metals/minerals) and Bhaishajya Kalpana (processing of herbals and herbo-mineral compounds) (Gupta et al. 2009). There are around 1000 Ayurvedic herbal formulae, of which very few have been tested or investigated in the modern laboratories and context. Animal products such as bones and flesh of goat, fish, pecking bird, and aquatic and marshy animals are also utilized in preparation of Ayurvedic medicines. Minerals such as gold, zinc, iron, copper, and mercury are also used and are prepared as an ash (Bhasma) (Dasgupta, 2011). Not only minerals but nano-hybrid materials made from mine tailings have also showed prominence in case of drug formulation (Deshpande et al. 2024).

Variety of geo-materials such as minerals etc. are used after incineration and incinerated minerals are termed as 'Rasa'. In Ayurveda, Rasa refers to the Parada (Mercury), and also Maharasa, Uparasa, Sadharana rasa. Minerals and metals are efficacious and potent for immunization, rejuvenation, and the elimination of the diseases (Rawat and Tripathi, 2022). Renowned scientists have acknowledged, introduction and evolution of various processes and techniques of purification of toxic metals and materials led to the innovation in chemistry and pharmaceuticals further contributes in modern chemistry (Patwardhan, 2013). Although ayurveda holds potential to be CAM but, various difficulties arose due to variation in potency related to difference in species, non-availability of unified coding for the commonly used different species, difference in geographical locations, misinterpretation and adulteration of drugs, non-uniformity in quality control standards, contrasting processing methods all these factors contribute to the obscurity regarding the ayurveda (Jaiswal and Williams, 2017). Current paper discusses the role of geological materials in the ayurvedic medicines (Geopharmacy). We also present an interesting discussion on the minerals pyrite (FeS₂), which is known as 'Raupya-Makshika' as 'vimala' in Ayurveda, and also present our views on these terminologies based on the physical properties of these minerals mentioned in the ancient ayurvedic texts.

2. METHODOLOGY

The current study presents a collection of information on geomaterials in ayurveda and focuses on solving controversy between swaran-makshika, raupya-makshika and vimala. Study was initiated with systematic literature searching from various databases including PubMed, Scopus, Google Scholar, and also traditional ancient ayurvedic texts from internet archive. Various journals, and reports were also reviewed. The search strategy included a combination of keywords such as 'Ayurveda', 'Rasashastra', 'Traditional medicine', 'swaran-makshika', 'vimala', 'chacopyrite',



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‘pyrite’. Detailed screening of articles was carried out to identify relevant studies focusing on the geological characteristics, chemical composition, pharmacological properties, and therapeutic uses of these geomaterials in Ayurvedic medicine. Articles were selected on the basis of relevance to the topic, methodological accuracy, and contribution to understanding controversies and applications. The selected literature then organized accordingly, exploring both historical perspectives and contemporary debates surrounding the confusion of naming of swaran-makshika, raupya-makshika and vimala. Through critical analysis and synthesis of the literature, this review aims to provide insights into the traditional medicine, utilization of these geomaterials, addressing existing controversies, and highlight areas for further research and clarification in the field of ayurveda.

3. GEOLOGICAL MATERIALS IN AYURVEDA

Naturally occurring metal complexes are the building blocks of life processes, for e.g. Ca^{2+} metal is the main constituent of bones but, it helps to get rid of muscle cramps and many other cell activities. Similarly, Mg^{2+} also contributes to the cell activities. Along with Ca^{2+} and Mg^{2+} , Zn^{2+} , Cu^{2+} , Fe^{2+} and Mn^{2+} are also involved in the biological processes in the nucleus. Activity of enzymes and some of the most genetic processes in the replication of DNA and RNA are controlled by metals (Anastassopoulou and Theophanides, 1995). In the biological functions metals and minerals play a vital role. Mercury, Copper, Iron, Calcium, Zinc, etc. play important role in normalizing many metabolic activities but, may become toxic if administered in excess amount (Ciosek et al. 2023).

Rasashastra, originating in India, aimed to prolong life, maintain bodily health, and facilitate service to God for spiritual salvation. Mercury (Parada) was selected due to its unique properties, including its liquid form and shiny silver appearance. It was believed that solidifying mercury could yield silver and transform other metals into gold. Charaka asserted that human ambitions, such as longevity, wealth, and salvation, could be achieved through mercury, drawing ancient scientists to its study. As science progressed, Rasashastra expanded to include various minerals, metals, plants, and animals, leading to a broader scope in its practice (Dole and Paranjape, 2004). A link between geology and medical science has been established in previous studies (Randive and Hatekar, 2010; Duffin, 2013). It will not be an exaggeration to propose that the ancient doctors were experts in the medical sciences as well geology. Available literature has shown that the minerals such as mica, quartz, feldspar, fluorspar, chalcopyrite, pyrite, malachite, bismuth, zincite, sphalerite, sulphur, red and yellow ochre (haematite), orpiment, realgar, galena, stibnite, magnesite, native arsenic, amber, cinnabar, messicot, corundum, turquoise, beryl group, topaz, diamond, and many others such as salt petre, red sandstone, cowrie shells, corals, and mineral bitumen were also used as raw materials for preparation of medicines (Nandan, 2004). All these are classified into following categories, namely, Mahaarasa, Uparasa, Saadhaaranarasa, Dhaatu, Ratna and Visha. Various texts classify above mentioned minerals in these six categories (Dole and Paranjape, 2004). Table 1 gives classification of metals and minerals in Mahaarasa, Uparasa, Saadhaaranarasa, Dhaatu, Ratna.

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Table 1: Classification of minerals and metals according to the ayurveda indicates confusion in relevant identification of these substances in present times (Modified after Savrikar and Ravishankar, 2011)

Class of the substance		Minerals or metals under the class		
Rasas	Rasa	Parada	Mercury	Hg
	Mahaarasa	Abhraka	Mica	(K, Na) (Mg, Fe ²⁺ , Fe ³⁺ , Al) ₃ (Si Al) ₄ (OH) ₁₀
		Vaikrant	Flourspar (?)/Tourmaline (?)	CaF ₂
		Makshika	Copper pyrite	CuFeS ₂
		Vimala/Raupya-Makshikaa (?)	Iron pyrite (?)	FeS ₂ (?)
		Shailajatu	Black bitumen	Humic acids with elements such as Zn, Mg, K, Se, Fe etc.
		Sasyka	Blue vitriol	CuSO ₄ . 5H ₂ O
		Chapala	Bismuthinite	Bi ₂ S ₃
		Rasaka	Zinc compounds	ZnS or ZnO or ZnCO ₃
	Uparasa	Gandhaka	Sulphur	S
		Gairika	Haematite	Fe ₂ O ₃
		Kasisa	Green vitriol	FeSO ₄ .7H ₂ O
		Kankshi	Alum	KAl(SO ₄) ₂ .12H ₂ O
		Hartala	Orpiment	As ₂ S ₃
		Manashila	Realgar	As ₂ S ₃
		Anjana	Topical ointment	
		Strotonjana	Stibnite	Sb ₂ S ₃
		Rasanjana	Mercuric (II) Oxide	HgO

		Pushpanjana	Burnt alum (?) or Zinc (?)	$KAl(SO_4)_2$
		Nilanjana	Galena	PbS
	Saadhaarana rasa	Gouripashana	Arsenious oxide	As_2O_3
		Navasagara	Ammonium chloride	NH_4Cl
		Kaparda	Cowrie	$CaCO_3$
		Vahnijara	Ambergris	Ambrein
		Girisindura	Red mercuric oxide	HgO
		Hingula	Cinnabar	HgS
		Mriddarashringa	Litharge	PbO
		Dhatu	Dhatu	Suvarna
Rajata	Silver			Ag
Tamra	Copper			Cu
Loha	Iron			Fe
Mandura	Red iron oxide			Fe_2O_3
Vanga	Tin			Sn
Naga	Lead			Pb
Jashada	Zinc			Zn
Kansya	Bronze			Alloy of Cu and Sn
Pittala	Brass			Alloy Cu and Zn
Ratna	Ratna	Manikya	Ruby	Al_2O_3
		Mukta	Pearl	$CaCO_3$
		Pravala	Coral	$CaCO_3$
		Tarkshya	Emerald	$Be_3Al_2(SiO_3)_6$
		Pushparaga	Yellow Sapphire	Al_2O_3
		Hiraka	Diamond	C
		Nilama	Blue Sapphire	Al_2O_3

		Gomeda	Grossularite	$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$
		Vaidurya	Chrysoberyl	BeAl_2O_4
	Uparatna	Vaikranta	Flourite (?)/Tourmaline (?)	CaF_2
		Suryakanta	Spinel	MgAl_2O_4
		Chandrakant	Moonstone (Orthoclase)	KAlSi_3O_8
		Rajavarta	Lapis Lazuli	$(\text{Na,Ca})_4\text{Al}_3\text{Si}_3\text{O}_{12}(\text{S}, \text{SO})_2$
		Perojaka	Turquoise	$\text{CuAl}_3(\text{PO}_4)_2(\text{OH})_4 \cdot 4\text{H}_2\text{O}$
		Sphatika	Rock crystal (Quartz)	SiO_2
		Yomashma	Jadeite	$\text{NaAlSi}_2\text{O}_6$
		Palanka	Onyx	SiO_2
		Rudhira	Carnelian	SiO_2
		Puttika	Peridot	$(\text{Mg,Fe})_2\text{SiO}_4$
		Trinakanta	Amber	$\text{C}_{10}\text{H}_{16}\text{O}$

3.1. Case study

Progress in Rasashastra emphasized importance of Swarna (Gold), Rajata (Silver), Tamra (Copper), Loha (Iron) etc. along with Parada (Mercury) and were found therapeutically useful after processing them through various pharmaceutical processes such as Shodhana, Marana, Amritakarana etc. (Reddy et al. 2014). Swarna (Gold) is considered as superior among all other metals and effect of gold to the body is also appreciated by modern medical science and they are also using gold therapeutically in various chemical forms as medicine. In Ayurveda, gold is used to treat tuberculosis, anaemia, cough, debility, sterility, muscular dystrophy (Singh and Chaudhary, 2012). According to Rasendrapuran, gold is considered among the eight ferrous substances in which six are metals and two or alloys. Shloka from Rasendrapuran, (2019) and its explanation is given below:

सुवर्णं रजतं ताम्रं त्रपशीशकमायसम् । षडेतानि च लोहानि कृत्रिमौ कांस्यपित्तलौ ॥ अ. ११ श्लो. ३ ॥

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Explanation -: The gold, silver, copper, tin, lead, and iron are the six ferrous substances which are not created by alloying any two or more materials but, are formed naturally in the earth. Brass and bronze are also two ferrous substances, but they are created by mixing two or more metals, in other words they are alloys (Rasendra puran, 2019, Adhyay 11, Shloka 3). Geochemically, gold, silver, copper, tin, lead and iron are classified as sulphur-loving (Chalcophile) and oxygen-hating elements, and in presence of sulphur all these elements can be associated with the Iron (Misra, 2012).

But, in case of unavailability of gold, according to Rasendra Puran, Makshika can be used as an alternative medicine because, not only it possesses equal medicinal benefits like gold but also, it has its own medicinal properties.

न केवल स्वर्णगुणा वर्तन्ते स्वर्णमाक्षिके | द्रव्यान्तरस्य संसर्गात्सन्त्यन्येऽपि गुणा यतः ॥ अ. ११ श्लो. १८॥

किन्तु तस्यानुकल्पत्वात्केचिदना गुणाः स्मृताः । तथापि कांचनाभावे दीयते स्वर्णमाक्षिकम् ॥ अ. ११ श्लो. १९॥

Explanation -: Makshika not only possesses medicinal properties of gold but also possesses its own properties, and it can be utilized as alternative in case of unavailability of gold (Rasendra puran, 2019, Adhyay 11, Shloka 18 and 19).

4. DISCUSSION ON THE CONTROVERSY OVER RAUPYA-MAKSHIKA AND VIMALA

In the ancient civilization, there was an assumption that the coordination between a person's mind and body leads him to the connection with the God (Fosarelli, 2002). To remain healthy and for healing purpose, use of geological materials was common in ancient Indian practice from around 3000 BC. Ancient Indian medicinal systems commonly utilized minerals such as cinnabar, galena, realgar, and other vital native elements such as Au, Ag, Fe, Zn etc. in combination with herbs (Hasan, 2021). Lost knowledge of ayurveda was revived along with the freedom movement during 1920s and 1930s. During revival, ayurveda faced complexities, contradictions, paradoxes and inconsistencies which are natural to the revival process (Kanagarathinam, 2020).

“Sandigdha Dravya” is the term used for the controversial material. An ayurvedic or sanskrit literature describes a name of material used in ayurveda which do not exactly indicate the source of material but many a times gives its therapeutic utility (Keshari, 2022). India which is the land of multiple languages and traditions poses a problem when the same material has different name in another language. Sometimes a synonym or code name is used for the material which cannot be traced easily (Dixit, 2011). For example, Sasyaka i.e. Copper sulphate is also named as Tuttha. Along with this it is also named as Tamragarbha (Core material for copper) and Shikhigriva (Material possessing colour of neck of peacock) (Sarkar et al. 2019). This creates problem while making the medicine and producing inefficacious preparations (Mathad, 2019). Adulterants and substitutes are the common practices in case of the ayurvedic material. The adulteration or substitution may lead to the deterioration, admixture, sophistication, inferiority, spoilage and other unknown reasons. At present, substitution and adulteration of materials is the major problem in ayurvedic medical industry (Keshari, 2022).

In rasashastra there are different formulations prepared from minerals, metals and herbo-mineral drug formulations which are used in treatment of various diseases and considered to yield results in lesser time (Savrikar and Ravishankar, 2011). Materials in rasashastra are classed as ‘dravyas’, in each of the group of dravyas, various materials were classified. Some of these dravyas hold controversy regarding their origin, types, synonyms, vernacular names, structure and therapeutical properties. Here word controversy refers to the confusion or unjustified versions of these metals and minerals (Mathad, 2019). Several geo-materials such as Chapala, Vimala, Vaikranta, Agnijara, Kampillaka, and Kankushtha hold controversy regarding their name (Kotrannavar, 2012). Ayurveda also holds the controversy over the metal toxicity in its drug formulations (Bhalla and Pannu, 2022). Therefore, in such context clarity is necessary regarding the material used in the formulations of various drugs. Reasons for the controversy over the various rasadravyas is discussed in Fig. 1. One of such highly debated controversy between makshika and vimala is discussed in following sections.

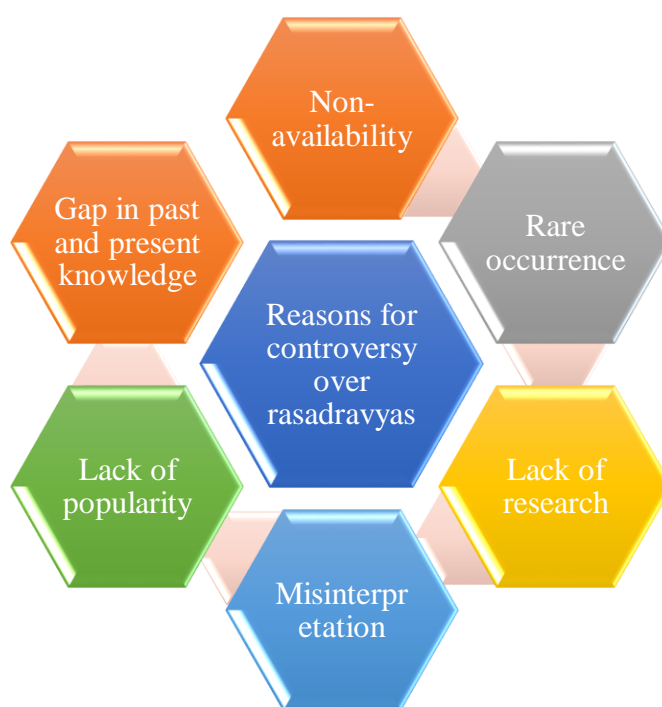


Figure 1: Reasons for controversy over the rasadravyas (Mathad, 2019)

4.1. Makshika and associated controversy

In various ancient ayurvedic texts such as Rasatarangini and Rasendrasarasangraha considers rajatMakshika and Vimala as one and the same material (Rasatarangini, 1989; Rasendrasarasangraha, 2019). On the other hand, texts such as Rasaratnasamuchchaya, Ayurvedprakash, and Rasaratnakara mentions vimala as separate entity (Rasaratnasamuchchaya, 2019; Ayurvedprakash, 1913; Rasaratnakara, 1966). Rasaratnakara considers vimala as Makshik (Rasaratnakara, 1966). Rasaratnasamuchchaya mentions three types of vimala (Rasaratnasamuchchaya, 2019). Such classification contradicts the fact of vimala to be the same as Raupya-makshika or Rajat-makshika or Tara-makshikaa. Therefore, lack of research and

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misinterpretation creates confusion (Mathad, 2019).

Makshika has been classified into two types; the Swaran-makshika and the Raupya-Makshika whereas, Vimala is classed as separate entity from the Makshika having different shodhana and marana process (Ray, 1909). Makshika is classified into two types viz. Swaran-makshika (Suvarna-Makshika) and Tar-Makshika or Rajat-Makshika or Raupya-Makshika (Rasendrapuran, 2019, Adhyay 11, Shlok 21). Following shloka describes it further (Rasendrapuran, 2019, Adhyay 11, Shlok, 21-23).

माक्षिकं द्विविधं हेममाक्षिकं तारमाक्षिकम् । अ. ११ श्लो. २१।

स्वर्णाभं स्वर्णमाक्षिकं निष्कोणं गुरुतायतम् । कृष्णतां विकिरेत्तु करे घृष्टं न संशयः ॥ अ. ११ श्लो. २२॥

स्वर्णवर्णं गुरुं स्निग्धमीषन्नीलच्छविच्छटम् । कषे कनकद्वष्टं तद्धितं हेममाक्षिकम् ॥

पाषाणबहुलं प्रोक्तं ताराख्यं च गुणाल्पकम् ॥ अ. ११ श्लो. २३॥

Explanation -: Makshika are of two types viz. swaran-makshika and tara-makshik. Makshika possesses lustre similar to gold, is without corners, dense, and soils black when rubbed on hand. It feels soft, and possesses blueish tinge and gives black streak with golden tinge when rubbed on streak plate and RaupyaMakshika along with accessory rock material is considered as low grade by Ayurvedic physician.

Rasendrapuran also gives classification of Makshika on the basis of colour and habit

माक्षिकं द्विविधं तत्र पीतशकलविभागतः । चतुर्द्धाकरसंस्थानाद्विज्ञेयं क्षेत्रभेदतः ॥ अ. ११ श्लो. २४. ॥

कदम्बगोलकाकारं शक्तिकापुटसन्निभम् । तथाङ्गुलीयकाकारं भस्मकर्तरिका समम् ॥ अ. ११ श्लो. २५ ॥

Explanation -: Makshika has two types on the basis of colour i.e. yellow coloured and white coloured and has four types on the basis of its occurrence viz. round like a Kadamba flower, resembling to pearl clam, finger like, and powdered like ash (Rasendrapuran, 2019, Adhyay 11, Shlok, 24-25).

Comparison between physical properties given in mineralogy and Rasendrapuran are given in Table 2. We have considered here bornite along with chalcopyrite because both have nearly same chemical composition.

Table 2 : Comparison between physical properties of Makshika, chalcopyrite and bornite.

Physical properties	Makshika (Rasendrapuran, 2019)	Chalcopyrite (Nesse, 2017)	Bornite (Nesse, 2017)
Habit	Round like Kadamba	Disphenoid crystals	Cubic, dodecahedral,

	flower, pearl clam shaped, finger like, powdered	which look like tetrahedron, may show octahedral habit and tetragonal prism	or octahedral
Colour	Golden yellow with blue tinge	Brass yellow with iridescence	Brownish bronze on fresh surfaces and quickly tarnishes to iridescent purple, blue and black
Lustre	Gold like	Metallic	Metallic if fresh and possesses iridescence
Streak	Black, possesses shine like gold	Greenish black	Greyish black
Cleavage	Without corners	Poor cleavage	Poor cleavage
Hardness	soft	2.5-3	2.5-3
Specific gravity	Dense	Dense	Dense

From the comparison given in the table it appears that the ancient ayurvedic texts mentions both chalcopyrite and bornite under the name of Makshika as properties of the both the minerals resembles with properties given in the text Rasendrapuran.

4.2 Vimala, Makshika, and Associated controversy

Rasatarangini mentions Raupya-Makshika which possesses silver colour as Vimala (Iron pyrite or Iron sulphide) (Rasatarangini, 21st tarang, Shlok 55) (Rasatarangini, 1989). But, Iron pyrite or pyrite possesses brass yellow colour. Also, it is harder than chalcopyrite and it tarnishes to black colour (Nesse, 2017). Rasaratnasamuchchaya mentions three types of Vimala (Rasaratnasamuchchaya, Adhyay 2nd, Shlok 9) and Raupyamakshika itself is a type of Makshika (Rasaratnasamuchchaya, Adhyay 2nd, Shlok 2) (Rasaratnasamuchchaya, 2019). Chalcocite, a mineral of copper also shows shiny lead grey colour with all other properties similar to chalcopyrite and bornite and it is distinguished from the bornite on the basis of its colour (Nesse, 2017). Therefore, it may be inferred that, chalcocite is the Raupyamakshika. Therefore, presenting Raupyamakshika as Vimala remains contradictory.

Rasaratnasamuchchaya, Rasendrapuran and Ayurvedaprakash mentions three types of vimala i.e. Suvarna-vimal, Rajat-vimal, and Kansy-vimal (Rasendrapuran, 2019; Rasaratnasamuchchaya, 2019; Ayurvedaprakash, 1913).

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विमलस्त्रिविधः प्रोक्तो हेमाद्यस्तारपूर्वकः | तृतीय कांस्यविमलस्तत्तत्कान्त्या च लक्ष्यते ||अ. २ श्लोक ९६||

वर्तुलः कोणसंयुक्तः स्निग्धश्च फलकान्वितः |

मरुत्पित्तहरो वृष्यो विमलोऽतिरसायनः ||अ. २ श्लोक ९७||

Explanation -: Vimala is categorized into three types viz. Suvarna-Vimala (Hema is synonym of Suvarna), Raupya-vimala, and Kansya-vimala. It is found to be spherical, possessing corners, smooth, and having flat surfaces or as flat surfaces. It is used in cure of diseases arising due to imbalance of Vata, and Pitta. It increases potency and is chemically potent (Rasaratnasamuchchaya, Adhyay 2nd, Shlok 96, and 97)

Iron sulphide or more specifically iron monosulphide are at the centre of the global biogeochemical iron and sulphur cycle. Infact, iron monosulphide solution is considered to have played major role in origin and evolution of life. Iron monosulphide solution co-exists with other sulphide mineral phases such as pentlandite (Fe-Ni sulphide), pyrite (FeS₂), and marcasite. Troilite (FeS) and pyrrhotite (Fe_{1-x}S) are end members of the iron monosulphide solution, which are metastable in environmental condition (Xu and Navrotsky 2010). Metastable iron monosulphide solution converts to pyrite and marcasite on sulphidation. Concentration sulfidic sulphur and ferrous ion is controlled by the parent iron monosulphide solution (Schoonen and Barnes, 1991). Also, pyrite, marcasite, and pyrrhotite have almost same physical properties. Although, arsenopyrite holds same structure and properties are marcasite but, it does not form solid solution with marcasite (Nesse, 2017) and therefore, pyrite, marcasite and pyrrhotite are taken for comparison of physical properties mentioned in ayurvedic texts and mineralogy book of Nesse is given in tables 3, 4 and 5.

Table 3: Comparison between properties of Suvarna-vimala and pyrite

Properties	Suvarana-vimala	Pyrite (Nesse, 2017)
Form	Circular or Flaky (<i>Rasaratnasamuchchaya</i> , 2019)	Framboidal
Colour	Golden yellow (<i>Rasaratnasamuchchaya</i> , 2019)	Brass yellow
Luster	Golden (<i>Rasaratnasamuchchaya</i> , 2019)	Metallic
Streak	Black (<i>Rasendrapuran</i> , 2019)	Black
Hardness	-	6-6.5
Specific gravity	Dense (<i>Rasaratnamuchchaya</i> , 2019)	Dense

Table 4: Comparison between properties of Rajata-vimala and marcasite

Properties	Rajata-vimala	Marcasite (Nesse, 2017)
Form	Circular or Flaky (<i>Rasaratnasmuchchaya</i> , 2019)	Flaky
Colour	silvery white (<i>Rasaratnasmuchchaya</i> , 2019)	White
Luster	Silvery (<i>Rasaratnasamuchchaya</i> , 2019)	Metallic
Streak	Black (<i>Rasendrapuran</i> , 2019)	Grayish-black
Hardness	-	6-6.5
Specific gravity	Dense (<i>Rasaratnasamuchchaya</i> , 2019)	Dense

Table 5: Comparison between properties of Kansya-vimala and Pyrrhotite

Properties	Kansya-vimala	Pyrrhotite (Nesse, 2017)
Form	Circular or Flaky (<i>Rasaratnasamuchchaya</i> , 2019)	Rosette form
Colour	Bronze yellow (<i>Rasaratnasamuchchaya</i> , 2019)	Bronze yellow
Luster	Bronze (<i>Rasaratnasamuchchaya</i> , 2019)	Metallic
Streak	Black (<i>Rasendrapuran</i> , 2019)	Black
Hardness	-	6-6.5
Specific gravity	Dense (<i>Rasaratnasamuchchaya</i> , 2019)	Dense

On the basis of above given comparison it can be inferred that, Suvarna-vimala is pyrite, Rajata-vimala is marcasite and Kansya-vimala is pyrrhotite.

4.3 Relation between Makshika and Vimala

Ray (1909) mentions Makshika as pyrite i.e. sulphide of iron (Ray, 1909). According to Rasendrapuran, Makshika is classified in two varieties viz. yellow coloured and white coloured. Also, Tapij which is another name for Makshika is classified as Vimala and Makshika (Rasendrapuran, 2019). Rasaratnasamuchchaya also categorizes Vimala as type of Makshika (Rasaratnasamuchchaya, 2019).

Another interesting fact is that, the Ayurvedaprakashgranthamala also mentions that, Vimala is the type of Makshika which is found on the banks of or in the basin of river Tapi (Tapti) (Tricumji, 1913). Tapi river originates at the Multai, Betul district, Madhya Pradesh (Patel and Srivastava, 2013) where, deposits of polymetallic Cu-Pb-Zn mineralization have been reported having pyrite, chalcopyrite, and pyrrhotite as ore minerals (Dora et al. 2023).

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In geological environments, it can be observed that, Fe can be replaced by Cu in pyrite structure and can form a solid solution with Fe. The formation of such solid solution is related to the hydrothermal conditions. During annealing, hydrothermally synthesized (Cu,Fe)S₂ solid solution decays further to FeS₂, CuS₂, and CuFeS₂ under dry hydrothermal P-T conditions (Schimid-Beurmann and Bente, 1995). Removal of iron and sulphur from the chalcopyrite (Cu₂S. FeS₂. FeS) leads to the development of chalcocite (Cu₂S), iron monosulphide solution (FeS), and pyrite (FeS₂) as the end product of enrichment during process of oxidation (Bastin, 1933), which proves the association and derivation of copper-pyrite, pyrite and iron monosulphide solution from (Cu,Fe)S₂ solid solution. Therefore, from above descriptions it can be concluded that, Makshika mentioned in the ancient ayurvedic texts refers to the chalcopyrite solid solution which is further classified into Swaran-makshika (Copper-pyrite), Raupya-Makshika or Rajat-Makshika (Chalcocite), and Vimala (Iron monosulphide solution). Vimala which further classified in Suvarna-vimala, Rajata-vimala, and Kansya-vimala are found to be pyrite, marcasite, and pyrrhotite respectively. All these can be classified as separate entities. Classification of the minerals discussed here is summarized Fig. 2.



Figure 2: Classification of Makshika i.e. (CuFe)S₂ solid solution into Swaran-makshika (Chalcopyrite), Raupya-Makshika (Chalcocite), and Vimala (Iron monosulphide solution) and further classification of Vimala

5. THERAPEUTIC USES OF MAKSHIKA AND VIMALA

5.1 Therapeutic uses of Makshika

SwarnaMakshikaa, also known as copper-pyrite, is considered a significant mineral in Ayurveda, dating back to ancient times between 300 BC to 600 BC. Copper Pyrite which is most abundant and has been processed according to Ayurvedic principles, undergoing various powder tests outlined in Rasashastra (Jadar and Shrikanth, 2019). SwarnaMakshikaa, upadhatu of gold, serves as a powerful Rasayana (rejuvenator) and undergoes purification and incineration to heighten its bioavailability. This process involves breaking molecular bonds and reducing particle size to nano-levels through methods like shodhana and marana. The resulting bhasma (ash) comprises crucial elements such as copper, iron, silicon, and trace minerals. Its minute particle size facilitates swift dissolution and targeted action within the body, enhancing drug delivery efficiency. SwarnaMakshikaa bhasma boasts diverse therapeutic properties, including rejuvenation, vitality enhancement, blood purification, and the treatment of conditions like diabetes, anemia, and digestive disorders (Nambiar et al. 2017). The Indian alchemical tradition is used therapeutically for conditions like anaemia, skin ailments, diabetes, and as an immuno-modulatory Rasayana (Jadar and Shrikanth, 2019).

XRD and FESEM analysis of Swaran-makshika Bhasma after Marana (Incineration) unveiled Iron and Oxygen as major components of the Bhasma, and other elements such as copper, sulphur, carbon, aluminium, calcium etc. were found in the traces and sulphur was found in the form of sulphide. Presence of oxygen suggests Bhasma is in oxide form (Bhardwaj et al. 2021). Copper influences disrupted glucose and lipid metabolism, while iron mitigates oxidative stress pathways, thereby curbing insulin resistance and dysfunction in β -cells, thus regulating blood sugar levels. The drug's properties, including its taste, post-digestive effect, ability to pacify pitta, promote fluid absorption, and enhance digestion, support its effectiveness in alleviating acidity-related conditions. Its ability to halt bleeding associated with acidity is attributed to its blood-stopping property. Furthermore, copper's protective effects extend to preventing gastrointestinal damage and demonstrating efficacy against ulcers (Nambiar et al. 2017). Swarna-makshika Bhasma also possess anti-oxidant property which prevents or reverses the lipid-peroxidation and thereby preventing the tissue damage due to failure of anti-oxidant defence mechanism (Jadar and Shrikanth, 2019). Swarna-makshikaa bhasma also acts as an anti-microbial drug which therefore can be used in treatment of skin diseases (Iyshwarya and Satpute, 2013). A patented drug to treat cancer has been formulated in which Swarna Makshikaa Bhasma is also an ingredient (Shetty, 2019).

5.2 Therapeutic properties of Vimala

Pyrite, abundant in nature, is believed to offer diverse health benefits. Shree Bhairav Anand Yogi, the author of the text Rasarnava mentioned for the first time about its medicinal importance in the 10th century A.D. In the 12th century A.D., Rasa Vagbhata, the author of Rasaratnasamuchchaya mentions vimala as Maharasa and explains physical properties in detail (Pandey et al. 2018). Historical and traditional medicinal research suggest that pyrite enhances circulation and promotes healing, possibly due to its iron content and crystal structure. It has been

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used in traditional Chinese medicine (TCM) and in the Indian Ayurvedic practices it is used in the form of bhasma for the treatment of Jirna Jwara (chronic fever), Shotha (edema), Pandu (anemia), Aruchi (anorexia), Arsha (piles), and Kamala (jaundice) and especially indicated in the diseases of Vata and Pitta Dosha dominancy and also to stimulate blood flow and treat circulatory issues (Patwardhan et al. 2005).

Not only mineral drugs play significant role in Indian traditional medicine but similar uses are also in the traditional Chinese medicine (TCM). Pyrite (Pyritum) is mainly prescribed in Korean and Chinese traditional medicine from ancient times, primarily to enhance bone formation, aid in fracture healing, alleviate blood stasis, and reduce pain (Nam et al. 2024). To ensure its clinical safety and effectiveness, pyrite is typically prescribed in a calcined or processed form. Research has focused on its role in promoting fracture healing as well as in the cure of inflammatory response and osteoblast activity at fracture sites (Liu et al. 2017). In traditional Korean medicine (TKM), pyrite is often used alone or in combination with other treatments, but there is limited clinical evidence to support its efficacy. In TCM, pyrite is commonly used in the form of Chinese patent medicine containing pyrite (CPMP), which has been the subject of several clinical studies. Chinese patent medicines (CPMs) are formulated using TCM principles and are widely used in clinical practice due to their efficacy (Choi et al. 2022). The Donguibogam, a Chinese and Korean medical encyclopedia, characterizes pyrite as neutral in nature with a spicy taste and no inherent toxicity. It is recognized for its therapeutic benefits in addressing palpitations, fractures, blood dispersion, pain relief, pus drainage, elimination of blood stasis, and muscle and bone connection. Pyritum is acknowledged as a bone-attaching medicine, known for its potent effects in regulating qi and promoting blood circulation. While primarily administered orally, there are suggestions that it can also be applied externally in powdered form (Hwang and Choi, 2023). The Osteosarcoma, which causes death, can be treated with the pyrite nanomaterials and has shown effective results (Li et al. 2024).

6. CONCLUSION AND FUTURE SCOPE

In conclusion, Swarna-makshika which is also named as Makshika is mentioned as well as widely accepted as chalcopyrite. Raupya-Makshika is only described as a class of Makshika whose purification and incineration processes are similar to that of Makshika. Ayurvedic text rasaratnasamuchchaya mentions name vimala and gives purification and incineration methods which are found to be different from the Makshika methods. This creates an ambiguity regarding raupyaMakshika and vimala. On the basis of physical properties which are mentioned in Ayurvedic text (Rasaratnasamuchchaya, 2019) and mineralogy (Nesse, 2017), we characterized Raupyamakshika as chalcocite whereas, vimala as pyrite class. Rasaratnasamuchchaya also mentions three types of vimala i.e. Suvarna-vimala, Tara-vimala, and Kansya-vimala. These minerals have been identified as pyrite, marcasite, and pyrrhotite. Reason for taking only these three minerals is that, they belong the same family of pyrite whose properties are nearly same. Therefore, these three minerals might be the minerals mentioned under the class vimala.

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When the geological association of chalcopyrite, chalcocite, and pyrite class was observed and compared to the description in ayurvedic texts, it was found that, Makshika mentioned in the ayurvedic texts represents solid solution series (CuFe)S₂ and chalcopyrite, chalcocite and pyrite appears to be byproducts. Therefore, Makshika is the solution series of (CuFe)S₂ from which chalcopyrite (CuFeS₂), Chalcocite (Cu₂S) and minerals of pyrite are possibly derived.

Similarly, the attention is drawn towards diseases caused due to consumption of raw Makshika i.e. chalcopyrite. These diseases are found to arise in the miners as a potent occupational hazard. Diseases such as loss of appetite, allergy, and asthma are found in miners (Tumane et al. 2019), which bears remarkable similarity to the description mentioned in the ayurvedic texts.

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