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The Matter of Chinese Painting, Case studies of 8th century murals

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Chapter 3

The composition of paint

Paint is usually composed of several substances that are mixed together to form a material the painter can work with. It first consists of a colorant that can be either of an inorganic or organic nature. The inorganic substances that I have come across are minerals that are found in China, and the organic substances are vegetable dyes and glues. Special attention is paid to substances that are organic in nature but seen as minerals in China; such as *zikuang*, shellac and *hafen*, clam-white.

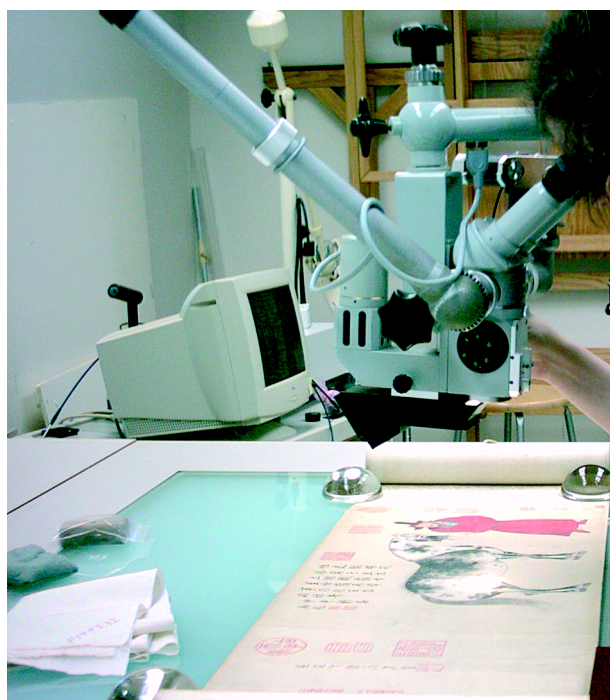
The second component of the paint is the binder or medium: the vehicle that carries the pigment or dye. For example, in oil painting this is some kind of oil, and in tempera gelatin or egg yolk. In the instance of the murals, a glue binder is used for both the mineral and the organic paints.

I will start here with a discussion of the minerals involved in painting, and then move on to vegetable dyes and some other related substances. The list of materials is incomplete, and the research on this topic must be seen as an ongoing process in which this study is a first step. For every material, a list of the many synonyms that are used in Chinese is provided, and pinyin transcription and translation of the terms is added. The index starting on page 206 can be used as a key to the terms.

Mineral paint

Mineral paint in China is dominated by local minerals such as cinnabar, red earth, malachite, azurite, realgar, orpiment, china clay and chalk. They are found locally or are imported from other areas in China; some areas have an abundance of these mineral ores. Apart from the more commonly-known minerals and colour names, there are some others of a more dubious nature. Mica, for one, is a mineral that is seldom mentioned in the discussion of techniques of art in arthistorical books, but from the examples given below we shall see that it was used in many wall paintings. I believe it was a commonly used to enrich the lustre of the paint layer.

Some of the minerals discussed in this chapter are not represented in the samples of the Tang Murals, and for that reason I sourced other examples. On three separate occasions I was kindly granted access to the storeroom of the Freer Gallery of Art, Smithsonian Institution, Washington D.C. (USA). Each visit involved spending many days using magnification to study works on paper and silk, and making photographs of details. These visits enabled essential information to be added to the data I had collected from the samples of the Tang murals. At this point I want to introduce the scroll painting ‘Horse and Groom’ by Zhao



Yong, dated 1347, Acc. No. F1945.32, Freer Gallery of Art. This is a painting on silk which I examined with a microscope.

Photograph 3-01

In the laboratory under the microscope: ‘Horse and Groom’ Acc. No. F1945.32, Freer Gallery of Art.

My observation:

The mane of the horse contains red, black and some pink lines.

The lips and the nostrils are pink: this pink is also visible around the groin and on the socks.

The hooves, by contrast, are brownish black, and brown is also present in the groom’s beard and hat. On the earring of the groom a trace of yellow is visible. The paint layer looks cracked, forming small islands of material comparable to the craquelure on old porcelain.

Each one of these small parts of the surface is slightly curled up on its outside rim. This aging effect is only visible on very close inspection.

The scroll will further be mentioned in the entries on cinnabar and azurite.



Photograph 3-02

Detail of 'Horse and Groom'

Cinnabar, *dan*, 丹

In the following samples I found sulphur, indicating cinnabar: YD3, YD5, YT3 and YT5; these results are also confirmed with SEM-EDX⁵⁹. I have visually confirmed the presence of vermilion under the microscope on the aforementioned scroll painting 'Horse and Groom'. The scroll was microscopically tested in July 1970 by Elisabeth West Fitzhugh and vermilion is also recorded in her report. The scroll was tested again in 1980 by John Winter, whose hand-written report is in the archive of the SCIRM: this report also contains the XRD-result of his testing, proving the presence of both azurite and vermilion.

Cinnabar, vermilion or mercuric sulphide is one of the oldest known mineral reds. In China, it is found in its mineral form in Hunan, Guizhou, Sichuan and Yunnan.⁶⁰ In Chinese painting, it is one of the earliest known mineral colours. It is a mercuric sulphide. The Chinese make a difference between natural cinnabar and the mercuric sulphide that is concocted by the Chinese in a simple refining process, the result of which is called vermilion.

⁵⁹ For the explanation of terms such as SEM-EDX see chapter 4, p 134.

⁶⁰ This section has been previously published in Dutch in [LVV, p 18] (See the introduction)

In Europe the use of cinnabar was, until the sixteenth century, mostly limited to the natural mineral. According to Rutherford Gettens there is some evidence of the process of artificially making cinnabar from mercury and sulphur in the recipes in a eight century Latin manuscript and in some Arab alchemist notes of the eighth or ninth century.⁶¹ By the seventeenth century the Chinese were exporting vermilion to Japan and the western world. The cargo list of the Dutch ships on average hold between 50 and 200 kilos of vermilion.⁶²

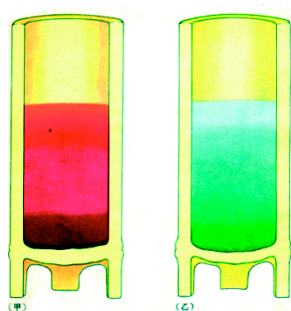
Yu Fei'an describes the ancient method of preparing cinnabar for the painter's use:

Cinnabar must be ground in a mortar. The finer the grain the better. Then it is put into a bamboo tube. At the bottom the bamboo tube must be a bit longer than the lowest partition. The tube must be clean and must be bound together using a lead thread to prevent it from splitting open. Use animal glue in the thicker solution and of it only the top clear solution. Mix this together with the cinnabar in the bamboo tube while adding clean water. Let it rest for an hour. Heat the tube *au-bain-marie* in an earthenware pot over a slow fire. It must not reach to boil therefore you must add cold water every now and then. When the cinnabar in the tube is almost dry, you must let the water cool down. Now wait for the cinnabar in the tube to dry up completely and remove the lead thread from the bamboo tube. Do not let it split by itself, but carefully cut it open with a knife. Now the tube contains a top layer of true red that close to the top will be yellow and this is called third-red; the bottom layer is called first-red and will be purple at the

bottom of it; in the middle we find a clear red which is called second-red. The three colors first-red, second-red and third-red are kept separately in different jars. [Yu 1, p 64]



(圖三) 乳 鉢



(圖四) 朱砂、石膏的澄漂方法

Photograph 3-03

The split bamboo tube with vermilion and malachite separated in three layers: the bottom layers are called 'first red' and 'first green'.

⁶¹ Gettens, Feller and Chase, 'Vermilion and Cinnabar', in Roy, Ashok, editor, *Artist Pigments Volume 2*, 1986, p 159-182.

⁶² Boxer, C.R., 'Dutch Merchants and Mariners in Asia 1602- 1795', Variorum reprints, London, 1988, p. 186-187.

The method described by Yu relies on the process of separating the size of the grains of the mineral into different layers. The coarser the grain, the heavier it is. The slow heating of the tube with the suspension of glue-water and cinnabar will start the process of separation into layers of different size grains, the heavier grains settling down before the finer and therefore lighter grains. This results in layers of different hues, and although Yu states that the finer the grain the better, I must say that there is a limit to this: The size of grain determines the hue of the colour, and the smaller grains display less colour than the coarser grains, so that if the mineral is ground too finely the colour will disappear altogether, leaving you with nothing more than a whitish powder.

The sublimation method of preparation is also used for malachite and azurite. The bottom layer is always of the deepest hue and will be called first-red, first-green and first-blue.

In western grinding techniques, this separation process is done in a different way, using a set of sequential sieves. This European method involves first grinding the mineral, and then ‘wet sieving’ it: putting it through a set of sieves, starting with a coarse-mesh sieve and gradually using a finer and finer mesh, in order to separate the grains by size.



Photograph 3-04

Cinnabar crystals on a matrix of barite.

In the twelfth century, Shen Gua writes about cinnabar in connection with the search for immortality that has been part of China's traditional alchemy from the dawn of their civilization. It seems that in the mind of alchemists, since the nature of this material is deadly, it must when changed in the right way also be able to give life, or even better: eternal life [Shen Gua, scroll 21, section 375, p 216]:

Xishi, 细石

The physician Cai Shining from Shuizhou once had a valuable Xi stone, and he said: "I received this from a Taoist over ten years ago." It is purple in colour and shining, like cinnabar sand from Chenzhou, but even more shining and brilliant, as if it enlightens people: I tested if it worked as a medicine; it was wrinkled; and heavy like gold and tin. On the top there are two or three dimples; with a small knife you can scrap some off,

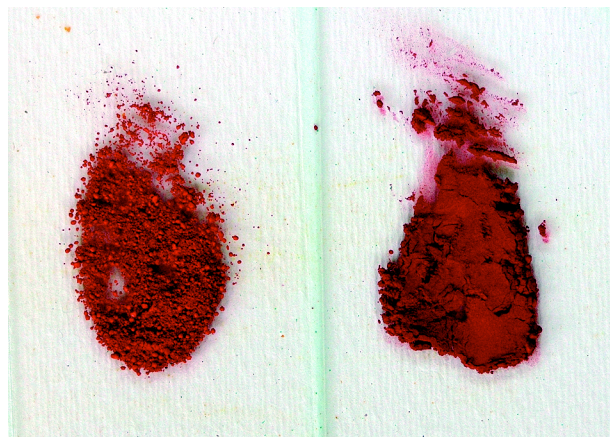
and what comes off is a red powder like cinnabar sand. If you take a grain the size of a hempseed, it will cure the diseases of the fool and of the heated heart. A pound of it will breathe for two years. Cai Shining did not know its name, but he entrusted it to me. There is said: "This is cinnabar medicine that was refined in the old days." The form and the colour are strange, it can breathe, it is not an ordinary substance, and it must be examined, identified and classified.

Another of Shen Gua's stories warns about the danger of a substance that is known for its use in alchemy [Shen Gua, scroll 24, section 432, p 238]:

Zhusha, 朱砂

Once, my cousin Li Shansheng, together with his companions, was refining cinnabar into vermilion; they had been at it for a year, and because they put the foam back into the kettle, a small piece fell to the ground. One of his companions formed it into a pill and swallowed it; he was taken over by dizziness and the same night he died. Cinnabar is a proper medicine and can even be given to a newborn baby, but when heated it transforms and it can kill people. When it comes to the reverse of this transformation, on the one hand it can be very poisonous, why can it not then be life giving on the other hand; so if it can kill people by transformation, this must be the reason it also gives life to people. It is just that this art has not yet been discovered. This is the immortals' method of gaining wings and ascending into heaven, it cannot be denied; but you still have to warn against it.

In the article 'Oracle-Bone Color Pigments', published in the *Harvard Journal of Asiatic Studies*, vol 2 No.1, march 1937; Roswell S. Britton described the paint material on oracle bones from the YinXu site in Anyang, which lies in the province Henan. At that time, oracle bones had already been studied for some twenty or more years. In what is probably one of the first attempts to analyse this material using scientific methods, Britton details the finding of cinnabar and an undefined black carbon. The black might be pigs blood in a degenerated form, but that could not be established at the time of publishing. He also mentioned pigs blood, together with powdered quicklime as a colourant for lacquer ware.



Photograph 3- 05
'First red' and' third red'.

A exhaustive list of synonyms for cinnabar, only in chinese characters, is published in the book 'Chinese *Materia Medica*', translated and edited by B.E. Read and C. Pak, in the section 'Compendium on Minerals and Stones' [henceforth: Read and Pak].⁶³

Cinnabar, cinnebarite, *Dan Sha*, 丹砂

Synonyms:

Zhusha, 朱砂[pearl sand]

Basha, 巴沙[Sichuan sand]

Yuesha, 越沙[Zhejiang sand]

Yunmusha, 云母沙[mica sand]

Machisha, 马齿沙[horse teeth sand]

Dousha, 豆沙[bean sand]

Mosha, 末沙[last sand]

Chensha, 辰砂[Chenzhou sand]

Liukong, 硫汞[liquid mercury]

Honghongkong, 红汞矿[red mercury]

Honghong, 红汞[red mercury]

Honghuang, 汞黄[mercury yellow]

Hongliu, 汞硫[mercury fluid]

Vermilion, levigated sulphide of mercury, *Yinzhu*, 银朱

Xinghong, 猩红[orangutan red]

Zifenshuang, 紫粉霜[purple powder snow]

⁶³ [Read and Pak, section IV, 2, p 49] Please note that for clarity of the terms I have edited their text, including the addition of transcription and translation, and that the index in back of this book can be used as a key to this and following lists.

Red Earth, *Haematite*, *chitu*, 赤土

In the loess ground layers of the samples YT1, YT2, YT3, YD1, YD3, YD5, SLA1, SLA2, the iron content was tested and confirmed with chemical analysis. These samples show Fe with a residue of small particles like sand and quartz which is consistent with the local loess reference sample. The red paint layers of the samples ZQX1, ZH2, ZH3, YT5, YD1, YD3, WM1/6a all contain iron (Fe), most likely in the form of iron oxide or red earth, but all are mixed with various other components.



Photograph 3-06, left
Red earth specimens,
as still sold by Chinese pharmacists.



Photograph 3-07, right
Grounded red earth,
as still sold by Chinese pharmacists.

Red earth is definitely the most common pigment in China. It is found in a broad band across the country, roughly between the Yellow river and the Yangzi. The region around Xi'an is literally made of this iron-rich earth. Red earth is very stable, and can be used in combination with a number of other pigments. Iron is the best indicator for red earth. Red earth is used in the bricks and in mud layers of the tombs, and it makes up the majority of the red color on the surface of the murals. One can indeed say that the walls are made of this material, although this is further complicated by the fact that the dust in the surrounding environment originates from the iron-rich loess ground. In the many centuries that have passed, the dust has had time to settle on the surface of the walls. Therefore, even when haematite is present in the sample

layer on top of the prepared whitewashed surface, it is not easily distinguished from the dust. I found that almost all samples in this study contained iron in one or more of the layers. Very careful separation of the various layers was essential to distinguish whether in either the background layer or the paint layer the iron presence indicated haematite.

Red Lead, *qian*, 铅

In none of the samples I have taken from the Tang Murals is red lead found. This is remarkable, since lead is believed to have been commonly used as a red paint in Tang paintings in this area and, for example, in the Dunhuang area. According to Yu [Yu1, p 20], Xia Nai, the famous father of archaeology in China, reports the following colors:

Altogether there are the following eleven types of raw materials: soot, kaolin, red ochre, azurite, malachite, cinnabar, lead white, red lead, indigo, gardenia yellow, and safflower (rouge).

And Yu comments on red lead and lead white [Yu 1, p 3]:

Red lead: This is the same as lead yellow, which is also called Zhang red. There are two shades of it used on murals, one deep and one pale.

Lead White: Mostly what was used there is 'kaolin' and white chalk. That which was mixed with vermilion and red lead and has turned black is lead white, and there is also white chalk.

Yu further states that the most important form of red pigment is left out; the red earth colour used by painters since ancient times: red ochre.

However, in the publications of the Shaanxi History Museum about the Tang murals, there is red lead mentioned as paint in the Yide tomb:

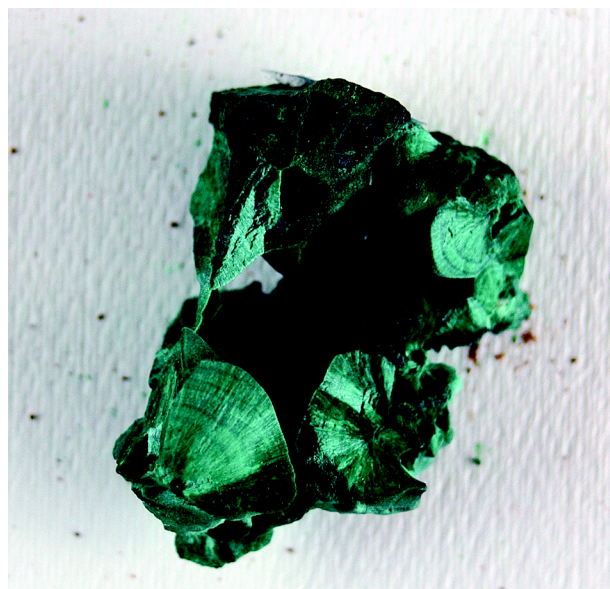
密陀僧, PbO, yellow

铅丹, Pb₃O₄, red

Nonetheless, I must testify that in the surface of paint that I have examined, at least, there was no presence of lead.

Malachite, *kongqueshi*, 孔雀石

The presence of Malachite was tested and confirmed with chemical analysis in sample YD2. Malachite is found in several places in China: it is still mined in Guangdong, in Sichuan, and in the Daye copper mine in Huangshi Hubei. Its connection with copper had already been documented by the Song dynasty. When I visited the department that prepares the painting materials for the Beijing school of Fine Arts, I saw the modern method of grinding malachite. This grinding is now done using a wet sieving method; the same method that is used in Europe, for example at the mill of Kremer pigments in Germany.



Photograph 3-08

Malachite specimen from the Guangdong mine in Sichuan province.

Malachite is found in the north west of China and on the Malian peninsula. According to Fan Chengda from the Song dynasty in his *Guihai Yuhengzhi*, (Chronicle of the South):

Green, west of the You River are places with copper, between the raw ore there are minerals called mineral green. There is also one kind that is as brittle as dry earth, it is called mud green. [Yu 1, p 5]

Yu Fei'an, writing in the 1950s, agrees with this when he says that Fan's view is consistent with the view of Yu's time, and that there are four kinds:

...mineral green, malachite, copper green and pebble green. Mineral green is formed in small lumps; the best kind is from Huize, Dongchuan and from Gongshan in Yunnan. The second-best in terms of quality comes from Nandan and Baoyang in Guangxi. It is also found in Iran and Burma.

Malachite is formed in lumps, and is by nature composed of light and dark layers. The colour is reminiscent of peacock feathers, and it is frequently used as an inlay in artisan's pieces. Loose pieces and fragments can be used to make a green color, and are so hard that they must be crushed with a hammer. After that, the pieces must be ground in a mortar, turning in one direction only. If they are ground in different directions, small balls of the mineral will form and the process cannot be reversed. [Yu 1, p 5]

Maimai Sze in the *The Mustard-seed Garden Manual of Painting (Jiezi yuan huabu)*:

The mineral is so solid it cannot be crushed. Take some ear wax and make small balls of it, than you can easily rub it into a paste. [Sze, p 37][*Jiezi yuan huabu*, 1983, part 1, p 28]

The ear wax keeps the mineral in its place so that it stays in the mortar when working on it. He also gives a method of use for the mineral green:

To make mineral green one must use the same method as for mineral blue. The mineral is so solid it first must be broken into pieces with a hammer. Than it can be ground further in a mortar. There is a kind called frog-back-green which is the best. It must be ground and mixed with water. Mineral green has three hues. If you suspend it in water it separates into three layers, the top one is first-green; the others are called second-green and third-green. Its uses are similar to mineral blue.

The glue must only be mixed in at the time of use. Use clear glue water in a dish. Add more water and warm it over a slow fire to dissolve the mineral green for use. After use the glue must be removed. There must be no glue left or it will affect the colour of the green or blue. To skim off the glue, use boiling water, and add it to the blue or green. Put it on *au-bain-marie*, and make sure no water is added; after a short while the glue will float to the top and can be skimmed off. This is called the 'skimming off' of the glue. If this is not done properly, the next time it cannot be used because the green and blue will not be brilliant. Shortly before the next use, new glue must be added. [Sze, p 38]

A long list of synonyms for malachite is published in the *Materia Medica* [Read and Pak, section IV, 2, p 49] [see also note 61]:

Kongqing, 空青[empty blue]

Malachite, large hollow variety.

Synonyms:

Yangmeiqing, 杨梅青[bayberry blue]

Similar to *Lüqing*

Qinglanggan, malachite.

Considered inferior to *Lüqing*.

Etc.

Cengqing, 曾青[layered blue]

Malachite, stratified variety.

Similar to *Lüqing*.

Qinglanggan, malachite.

Lüqing, 绿青[green blue]

Malachite, (fine granular CuCO_3 , $\text{Cu}(\text{OH})_2$).

Synonyms:

Shilü, 石绿[mineral green]

Dalü, 大绿[big green]

Lüfutong, 绿绋铜[green rope copper]

Lüsetongkong, 绿色铜筇[green colour copper]

Lüshi, 碌石[green mineral]

Lü, 碌[green]

Qinglü, 青绿[blue green]

Modern term:

Kongqueshi, 孔雀石[peacock mineral]

Photograph 3-09
Azurite and malachite combined
in a layered mineral specimen.



Azurite, qing, 青

Azurite is found in connection with malachite because they are chemically related.

Visual examination with a microscope confirmed the presence of azurite in the Yuan dynasty scroll painting⁶⁴ ‘Horse and Groom’: in the collar of the groom’s robe.

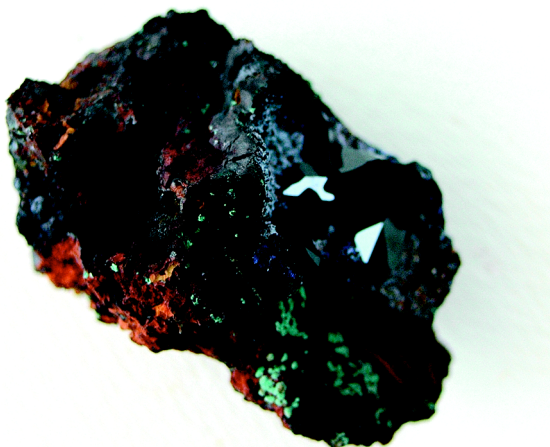
Observations under the microscope:

Azurite is clearly identifiable under the microscope. [see Photograph 3-02]

The scroll was microscopically tested in July 1970 by Fitzhugh, but she only noted in the museum records that vermilion is recognized. The scroll was examined again in 1980 by John Winter, and his report in the museum records contains an XRD-result confirming azurite and vermilion. Azurite was not found in any of my samples from the Tang Murals.

Azurite is the blue form of a mineral, and malachite is the green variety. Both minerals can be ground as a painter's pigment. The colour is partly defined by the size of the grains. In Europe, this mineral has been used since the Renaissance, and was called azure blue, copper lazaur, and mountain blue. In an oil binder azurite easily oxidizes to green, looking exactly like its 'brother' malachite. Even with the fresco technique, a green discoloring can arise from humidity. Malachite and azurite are both copper carbonate: see also the entry for malachite. [LVV, p 27]

⁶⁴ My own observation, further confirmed in private communication with Jennifer Giacciai.



Photograph 3-10

Azurite crystals on a matrix with some malachite.

These are Yu Fei'an's comments on azurite:

In the Liang dynasty Tao Hongjing 陶宏景 (painter and physician, 452 – 536) wrote in his book *Attached notes to the Famous Physicians* (*Mingyi bielu*, 名医别录): 'Azurite goes hand-in-hand with copper.' This conforms to the view of present-day scientists. The five forms are Azurite, Flat blue, Layered Blue, White blue and Grain blue. These are all poisonous. [Yu 1, p 4]

Azurite

The lumps look like bayberries. Su Song (稣颂 ± 1058) from the Song dynasty says: "It is found in Raozhou and Xinzhou, the form is like bayberries that are hollow; pound it flat to form a syrup; it is hard to find. (See the *Illustrated Materia Medica*, Tujing Ben Cao, 1596, Li Shizhen). Painters and physicians love to talk about azurite, they say it comes from gold mines or copper mines. I (Yu Fei'an) have only seen it being mined in Sichuan. There its form resembles berries of azurite, there are crevasses in the surface but there is certainly no syrup, and it is also not very useful. [Yu 1, p 4]

Flat blue

Flat blue comes from Yunnan and Burma. The Yunnan variety is called Yunnan blue: 滇青, *Dianqing*. The Burma variety is called Burma blue: 甸青, *Dianqing*.⁶⁵ This is the *Meihuapian* mentioned by Wang Gai in the *Jieziyuan Huazhuang* in the Qing

⁶⁵ The pinyin transcription (and many other transcription-systems) adds more to the problem of translation than it resolves, because of the similarity of 'dian' and 'dian'. Such problems only arise in an alphabet, since for any Chinese reader there is a clear difference between the characters for *dianqing* 滇青, and *dianqing* 甸青.

dynasty. The lumps from Burma are much larger but not as beautiful as the Yunnan lumps. [Yu 1, p 4]⁶⁶

Layered blue

The layered blue has alternating dark and light layers, or it has only dark layers. Painters prefer the light colored ones. The light color is collected and then ground to powder. The blue deriving from this is called Tianqing, Sky-blue. It is found in Shanxi, Hunan, Sichuan, Xikang⁶⁷ and Tibet. [Yu 1, p 4]

White blue

White blue is also known under the name of jade blue. It comes from Yunnan, Guizhou and Sichuan. It is even lighter than sky blue and does not shine. It is not greatly used by painters. [Yu 1, p 4]

Grain blue

Grain blue is also known under the name of Buddha-blue and Hui-blue. This pigment stems from the area west of Dunhuang. In the ancient Chinese texts, nobody mentions this. In all the Buddhist paintings and wall paintings grain blue is used, both for the wall paintings in Dunhuang as well as for the Buddhist paintings of the Ming and Qing dynasties. There are two sorts: one is a coarse grain, and the other has finer grains. The coarse-grained variety has both larger and smaller grains, while the fine-grained variety has finer grains which are not as fine as powder. Every packet holds 48 *liang*.⁶⁸ It is still available in areas such as Xikang, Tibet and Xinjiang. In peasant painting the Tibetan variety is called Tibet blue. [Yu 1, p 4]

The Hui form an ethnic minority group in China, lending their name to this form of blue. Hui blue is also mentioned by Needham as a candidate for blues in the smaltite or cobaltite group.⁶⁹ In the Chinese texts that are used for this research I have found no record of this Buddha-blue or grain-blue as described by Yu Fei'an. Azurite, like cinnabar and malachite, is

⁶⁶ According to Needham [Science and Civilisation in China, vol 5, part 2, page 169] 'flat blue' is possibly smaltite or cobaltite.

⁶⁷ An area in south west China, now part of Sichuan and Tibet.

⁶⁸ *Liang*, 两: a measure of weight 1 *jin*, 斤, is equal to 16 *liang*. 1 *jin* is 500 gram.

⁶⁹ Needham, J. and Lu Guai-Djen, Science and Civilisation in China, vol 5, Chemistry and chemical technology, part 2, Spagyric Discovery and Invention: Magisteries of Gold and Immortality, page 169.

one of the pigments that can be separated into different layers by the sublimation process described under the entry for cinnabar. As before, a list of synonyms for azurite is published in the *Materia Medica* [Read and Pak, section IV, 2, p 50]:

Azurite, *pianqing*, 扁青

Synonyms:

Shiqing, 石青 [mineral blue]

Daqing, 大青 [big blue]

Lantong, 蓝铜 [blue copper]

Modern term:

Lantongkuang, 蓝铜矿 [blue copper ore]

Pianqing or *Daqing* (also called *Yangqing*) is cobalt or *Lapis armenus*, a kind of zaffer, or 'powder blue', or smalts, prepared by roasting the native arseniuret [sic] of cobalt.

Cambodia is said to yield *Pianqing*. It contains silica and potash.

Baiqing, 白青

Light-coloured azurite, in round pieces the size of fish eyes.

Polygonum tinctorum is termed *Daqing*, 大青,

This refers to the dye indigo.

Said to be the same as *lüqing*.

Lüfuqing, 绿虜青 [green skin blue]

An old name for an azurite remedy for insect and snake bites.

Synonyms:

Tuiqing, 推青 [push blue]

Tuishi, 推石 [push mineral]

Bishiqing, 碧石青 [gem stone blue]

An indefinite substance from azurite, similar to the above.

Another form of green pigment which differs in chemical composition from the minerals malachite and azurite, is found in the *Materia Medica* [Read and Pak, section V, p 72]:

Lüfan, 绿矾

Ferrous sulphate, green vitriol, copperas.

Synonyms:

Heifan, 黑矾 [black vitriol]

Zaofan, 皂矾[black vitriol]

Qingfan, 青矾[black vitriol]

Jiangfan, 礬矾[drill vitriol]

Fanhong, 矾红[vitriol red]

Qingfanyin, 青矾银[black vitriol silver]

Yatieliusuan, 亚铁流酸[ferrous sulphate]

Modern terms:

Liusuanditie, 硫酸低铁[sulphate low grade iron]

Tieluqiangfan, 铁流强矾[molten iron strong vitriol]

Liusuantie, 硫酸铁[sulphate iron]

It is sold in broken masses of green crystals of great purity, and little disposition to oxidize, even in the damp atmosphere of China. It is made from sulphurous coal with hepatic iron pyrites, and allowing spontaneous chemical action to take place, the heap being plastered over with mortar to exclude the air. At Changdefu in Henan sulphate of iron is calcined to produce the sesquioxide of iron used as a pigment.

Peking sample⁷⁰:

SO₄ 35,4 %,

H₂O 38,3%

Metals Fe and a trace of Na

Contains traces of chloride (N). It is copper sulphate (*hu*). Acetate of copper also termed *Lüfan*. Synonyms *Tanfan*, see *shitan*, 石膽。

Fanhong is literally *roseate alum*, merely ferrous sulfate. *Jiangfan* also is merely sulfate of iron, decomposed to a red powder by prolonged heating.

Fan is best translated as a salt. It was adopted for many years in modern chemistry as the equivalent of the suffix –ATE applied to salts.

Used as a dye and as a fertilizer in Hangzhou. 70.000 piculs exported in 1924. It is manufactured today In the provinces Hunan, Sichuan and Anhui. The best grade is called *mianfan*, 面矾. The lowest grade is *difan*, 低矾.

⁷⁰ Note that this citation including the sample is from Read and Pak, they only give chemical terms in connection with their samples, and not for any other terms. [Read and Pak, section V, p 72].

This might be connected to the material that Shen Gua was already discussing in the twelfth century; a copper sulphate that could have been used for painting. However, Shen implies another, more lucid interpretation[Shen Gua, scroll 25, section 455, p 248]:

Kuquan, 库券, *Tong*, 铜

In Yanshanxian in the district Xinzhou is an acrid source that flows into a mountain stream. If you scoop up the water and boil it down, it becomes copper sulphate, and if you cook this copper sulphate, it becomes copper; if you boil down the copper sulphate in an iron kettle after a long period it will change into copper as well. That water can produce copper and that matter is transformed, is this not inconceivable? According to the Huangdi Suwen: "Heaven has five phases, the earth has five phases, the spirit of the earth is the 'damp' of heaven: earth can bring forth metal and stone, so damp can also bring forth metal and stone." This is the proof. If water drips on an underground stone, stalactites and stalagmites are formed on the place it drips. If at the Spring equinox or at the Autumn equinox water is scooped from a spring, stone flowers will form.⁷¹ Under the silk marshes *yinjingshi*, 银精石 [silver-extract mineral] is formed. Both are made of damp. Just as the spirit of wood becomes wind in heaven, when the wood brings forth fire, so the wind can bring forth fire, and I say these are the five phases.

Auripigment, mineral yellow, *shihuang*, 石黄

Auripigment or mineral yellow has two forms, realgar [As_2S_2] and orpiment [As_2S_3]:

Realgar, *xionghuang*, 雄黄

Realgar was not identified in any of my samples of the Tang Murals.



Photograph 3-11

Realgar specimen from the Shimen mine, Hunan, China.

⁷¹ 'Stone flower' are famous for their beauty; they are (mostly black) stones with white veins in the shape of chrysanthemums or other flowers.

Orpiment, *cihuang*, 雌黄

Orpiment has been microscopically identified in two paintings in the Freer Gallery of Art by the FGA: acc no 35.11 and the scroll painting of Guanyin of the Water moon, China, Gansu province, Dunhuang. Northern Song Dynasty, 968.

The painting is registered as Song Dynastic Painting, dated 968, acc no 30.36; Avalokitesvara with two attendant divinities; the family of the donor, including four persons, below. The yellow colour on the large vase in the centre of the painting is orpiment.

The mineral forms of realgar and of orpiment are distinct, but still the Chinese sources do not always clearly differentiate between realgar and orpiment. Orpiment is a transparent amorphous mineral, citrus-yellow or brownish-yellow in colour. Realgar is a bright red crystalline mineral. It transforms into an orange-yellow powder when ground. In Europe, its most common use was in Tempera painting. Tempera is a painting technique that uses water-soluble binders like animal glues, egg white, egg yoke or casein. Orpiment and realgar are still used in watercolours today. Ochres are also used in a yellow variety, mostly named after the place where they are found. [LVV, p 24]

Photograph 3-12

Guanyin of the Autumn Moon; Northern Song dynasty 968; Hanging scroll (mounted on panel); ink and colour on silk; 107.1x 59.1 cm.; Acc. No. F 30.36, Freer Gallery of Art





Photograph 3-13

Ksitigarbha and attendants in a landscape; Song dynasty (960-1279CE); ink and colour on silk; 106.4x58.2 cm.; This painting on silk said to have been found at Dunhuang; Acc. No. F 35.11, Freer Gallery of Art.

According to Yu Fei'an realgar, orpiment and yellow ochre are all parts of one substance and they are mined together:

This is sulphur arsenic and very harmful for ones health. Mineral yellow is yellow in colour, and realgar is orange; orpiment is gold yellow, and ochre is earth yellow. It is primarily found in Gangsu, but the biggest realgar mines on earth are in Hunan. None of these four yellows can be used together with lead. [Yu 1, p 3]

Mineral yellow

Mineral yellow is also called gold yellow: the outer layer is porous, dark in colour and it smells awful, while the inner layer is the proper mineral yellow. [Yu 1, p 3]

Realgar

Orange is found inside the mineral yellow, and is covered by it. It is also found in lumps without an outer layer. There is also a variety that is shiny and of a deeper color: this is called the 'spirit of realgar'. [Yu 1, p 3]

Orpiment

Orpiment, female yellow is found in mineral yellow. Its parts are small, like mica, it falls apart easily, as a Chinese proverb states: 'One ounce of orpiment gives off a thousand gold flakes.' [Yu 1, p 3]

Yellow ochre

Yellow ochre covers the outside of mineral-yellow, and smells the worst. In fact, the three mentioned above all smell a little. The primary components are iron oxide and iron hydroxide. It is also used for ceramics. [Yu 1, p 4]



Photograph 3-14

combination of orpiment and realgar specimen from the Shimen Realgar Mine, Hunan, China.

Shen Gua uses orpiment to correct mistakes in books [Shen Gua, scroll 1, section 18, p 26]:

Cihuang, 雌黄 [female yellow]

If there are mistakes in the new books of the public office, one uses orpiment to correct them. I have compared this with other methods of changing the character: scrapping and washing damages the paper; gluing onto the paper quickly becomes loose; spreading powder does not remove the character, as after repeated spreading it is still there. Only orpiment is capable of removing it at once, and it does not come loose again. It use to be called *qianhuang* 钱黄, lead yellow, this is used most often.

The use of orpiment as a pest controller is recorded much earlier in the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 227]:

The way to treat texts with orpiment:

Rub the orpiment on a gray hard stone till it is ripe; let it dry in the sun; rub it again in a porcelain bowl till it is even ripier; dry in the sun; and rub once more in the porcelain bowl. Now melt clear glue and put it in a mortar with an iron pestle, and pound it till it is ripe. Form pills like ink pills; dry in the shade. Take water and rub it to treat the text, then it will never deteriorate. If you use it directly from the bowl, no matter how much glue is used it will still deteriorate. For all texts that are mended with orpiment, the yellow remains beautiful after treatment; while the former yellows shed their colour.

In the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 226], a description of the process of dyeing yellow paper with *huangbo* precedes the section translated above. The ‘former yellow’ mentioned here relates to the use of *huangbo*, which is obviously seen as an inferior method of pest protection for texts, in view of its bleeding of colour (see also the entry on *dihuang* below).

Synonyms specified in the *Materia Medica* once again point out that in China realgar and orpiment both are mineral yellow. [Read and Pak, section IV, 2, p 32]:

Realgar, *Xionghuang*, 雄黄[male yellow]

Huangjinshi, 黄金石[yellow gold mineral]

Shihuang, 石黄[mineral yellow]

Chouhuang, 臭黄[foul yellow, stinking yellow]

Xunhuang, 熏黄[smoke yellow]

Mingxiong, 明雄[clear realgar]

Tuxiong, 土雄[earth realgar]

Piliugong, 璧硫汞[sharp mercury]

Guihuang, 瑰黄[jade yellow]

Shenhua'erliu, 神化二流[divine second class]

Xiongjing, 雄精[male spirit]

Shenliu'erhuang, 神硫二黄[divine second grade yellow]

Modern term:

Jiguanshi, 鸡冠石[cocks comb mineral]

Orpiment, *cihuang*, 雌黄[female yellow]

Shihuang, 石黄[mineral yellow]

In some cases the synonyms relate to the physical appearance of the mineral. The term ‘cock comb mineral’ is easily understood looking at photograph 3-11 with a red mineral form of realgar against a white calcite matrix.

Graphite, *heise*, 黑色 and Coal, *mei*, 煤

According to Yu Fei'an, graphite is produced in Hubei and Hunan, and it is sold as a medicine in Chinese drugstores. By nature, the material sticks to the tongue, and it differs from coal (carbon, *mei*, 煤), although its main component is also carbon. The old masters used to grind it up and use it to paint hair and eyebrows when figure painting. [Yu 1, p 10] The SEM result of the sample YD 4 indicates the presence graphite: the flat particles seen in Photograph 4-19 are typical of graphite.

Whitewashing of walls.

Shen Gua on the whitewashing of walls [Shen Gua, scroll 21, section 358, p 209]:

Bai E, 白垩

In the period 1034 – 1038 in Suzhou was a person that in one night whitewashed every wall with *bai e*, and it looked like the character *zai*: this slowly disappeared. In one night this was done to the houses of over ten thousand people without exception, even the sleeping quarters and the most hidden places; there was not one window or door excluded. Nobody knows how this came about, and it never happened again afterwards.

Chinese Technology in the Seventeenth Century by E-tu Zensun and Shio-Chuan Sun, 1966, is a translation of Song Yingxing's *Tiangong kaiwu* [Song 2, p. 147], here we find two varieties of china clay:

Non-glutinous rice is clay: [China clay, *gaoling*, 高齡]

Glutinous rice is clay: [China stone]

China clay is *Gaoling*, the same material (kaolinite) that is used for fine porcelain: it is a white aluminum silicate produced by the decomposition of granite or feldspar. China stone is another compound of aluminum and silicon that is fusible. Together they form the body of porcelain. The china stone, together with lime, can be used for glazing.

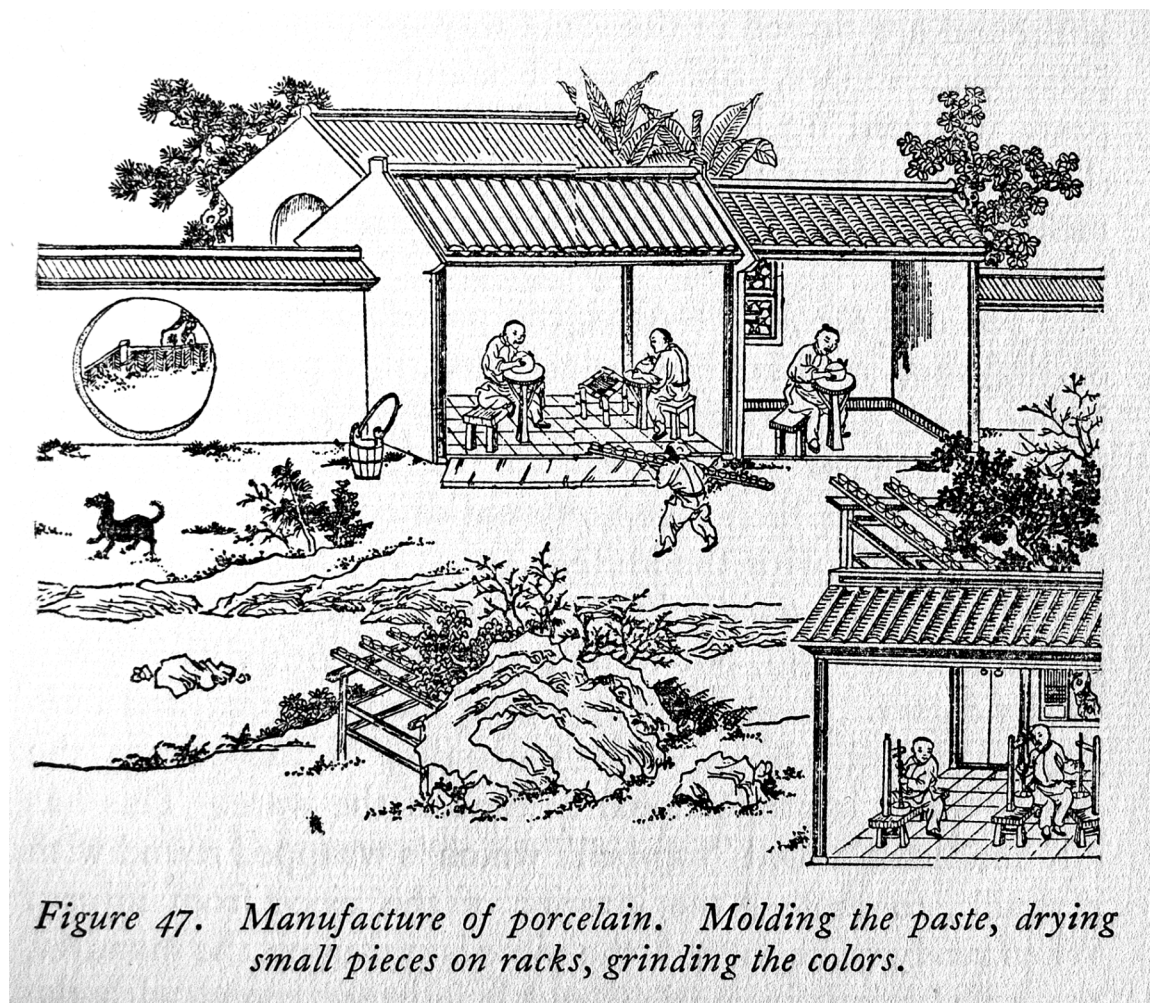


Figure 47. Manufacture of porcelain. Molding the paste, drying small pieces on racks, grinding the colors.

Photograph 3-15

Taken from *The chemical arts of old China*, Li Chiaoping, 1948, p. 93, figure 47.

In the foreground of Photograph 3-15 can be seen the grinding of the colours for porcelain: mortars are placed upon low benches, and the colours are ground by hand with pestles, which are supported by wooden poles fixed upright to the bench.

Gaoling is also used in painting, and in the ground layers of murals. In several samples I have found traces of *gaoling*. The microscope image Photograph 4-05 shows the typical feathery structure of the *gaoling*.



Photograph 3-16

Clam shell specimen as still sold by Chinese pharmacists.

Clam white, *Gefen* or *Hafen*, 蛤粉

In one sample YD2 the white is a mixture of 50 % chalk and 50 % aragonite. Aragonite is a form of calcium carbonate that occurs in corals, pearl and shells.⁷²

In Chinese painting, there are several whites in use, such as lead white, chalk, gaoling⁷³ and a special white called *Gefen*. The most commonly-used translation for *Gefen* is oyster white, which leads to a misunderstanding of the nature of *Gefen*: although the material is white and made of a shell, it is not made of oysters. To complicate the issue even more, there is such a material as oyster white, which is made of oyster shells and is used in building as a mortar, in the same way as the lime that is made by burning stones. It is also mixed with tong oil for use as a whitewash for ships.

Song Yingxing in his book *Chinese Technology in the Seventeenth Century* (*Tiangong kaiwu*) written in the seventeenth century, explains the difference [Song 2, p 202]:

Some people mistake clam shell powder for oyster lime. That is because they have never troubled themselves to learn the nature of things.

⁷² Formulation adapted from the electronic database CAMEO, by the Museum of Fine Arts in Boston, USA.
url: http://www.mfa.org/_cameo/frontend/home.asp

⁷³ *Gaoling* is china clay, in Europe it is known as kaolin.

It is possible that in some periods painters used oyster white instead of clam white. Oyster white is obtained by burning old oyster beds [*li-fang*, 蛎房] along the sea coast. The burning process involving charcoal turns it into a lime that is ready for use. Chemically clam white and oyster white are the same: calcium carbonate Ca CO_3 . The difference can, however, be shown by XRD, since oyster white contains only a little aragonite, while clam white is made up of almost 100% aragonite.



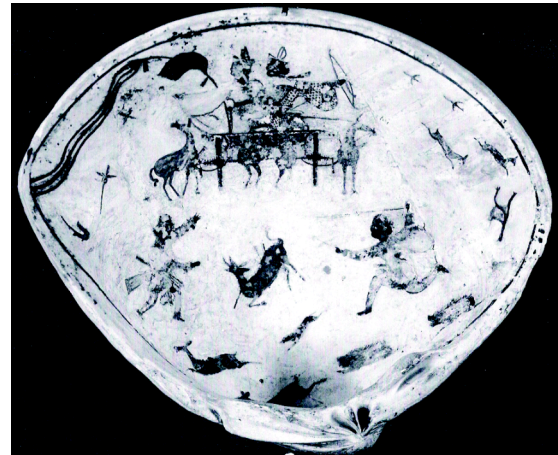
Photograph 3-17; Fossilised clam shell.

In the gilded lines on statues of the *Shui Lu An* ⁷⁴ the use of clam white is proven by the XRD method.⁷⁵ This makes me wonder about the availability of this material, since the gilded lines are obviously overpainted with gold: there is no visual reason for *Gefen* to be used in this particular example. There might, however, be a structural reason: the lines are laid onto and are in relief on the statue. It may well be that this substance provides a smoother or denser base than others and therefore is easier to use for the haute relief lines of the gilding, or it may be that the gold attaches to this lime particularly well.

⁷⁴ Temple in the Xi'an area.

⁷⁵ Private communication with Catharina Blänsdorf.

In the Chinese collection at the Cleveland Museum of Art, I found a double clam shell with paintings on both the interior sides.



Photograph 3-18a+b; Double clam shell with painting on both interior sides: left: *The Hunt*, China, dated to the Late Zhou, Qin or early Han dynasty; right: *The Kill*, dated between the Eastern Zhou Dynasty (771-256BCE) and the Han Dynasty (206BCE-220CE); painted clam shell; 7.5 x 9 cm. Photographs by courtesy of the Cleveland Museum of Art.

These paintings are very fine depictions of a hunting scene with people, horses, a carriage, deer, fish and flying birds. The shell supposedly dates to around the second or first century BC, either late Zhou, Qin or early Western Han, and was found on the Eastern seaboard of northern China.

This does not mean that clam white was used in that period, but it does prove the value of these particular kind of shell, especially since it was seen to be fit for such a fine painted scene. Yet another use of these shells, for giving silk a lustrous finish, is described in the *Chinese Technology in the Seventeenth Century* (*Tiangong kaiwu*) [Song 2, p. 59]:

After being boiled, [the fabric] is quickly spread out to dry in the sun. Next, in order to bring out the entire lustre in the silk, it is thoroughly polished with a large, round, smoothly-ground piece of clam shell.

In the *Materia Medica* [Read 1, p. 57] several entries shed light on the sort of clam that is used for painting material. In entry 225:

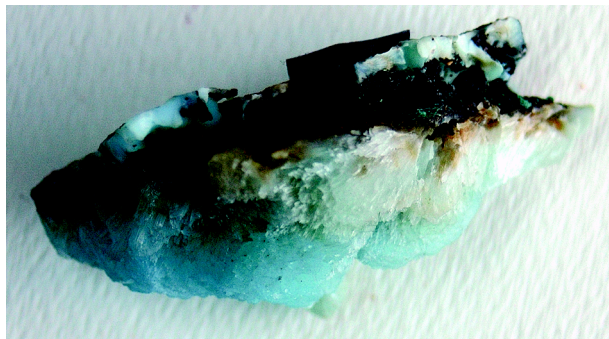
蛤蜊,

Keli, trough shells.

Li Shishen says that of the mollusc group this is beneficial to man, hence the name *li*.

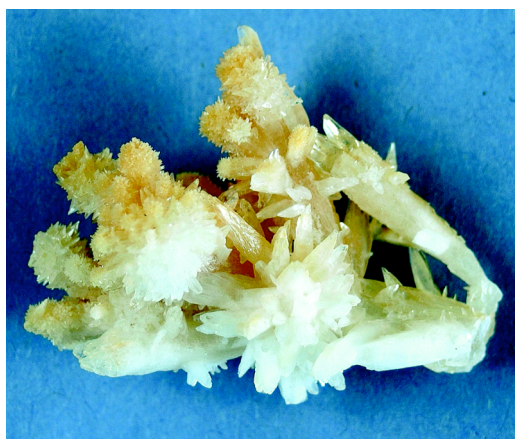
Wang Chi says they occur in the East and South Seas, white shells with a violet-

coloured lip (inside rim), two or three inches in size. Fukienese and Chekiang people use the meat as seafood; they also make a sauce, and the shells are roasted and powdered to make '*kelifen*', clam shell powder.



Photograph 3-19

Blue aragonite specimen from Wenshan, China.



Photograph 3-20

Aragonite specimen from Guilin, Guanxi province, China.

In addition, in entry 225 b.:

蛤蜊粉,

Kelifen, clam shell powder.

Synonyms

海蛤粉,

Haikefen,

Li Shishen says that this is a mixture of all kinds of seashells from clams and oysters as distinct from fresh water products and powdered mussel shells. There is a kind of drug of threadlike appearance, which disintegrates in water called *haifen*, 海粉, which on account of its name is bought by mistake. Being collected from the sea beaches it is good for removing phlegm and is demulcent.

Properties: saline, cooling and non poisonous.

Directions: according to Chu Chenhong, because clam shells have been calcined they cannot be put into decoctions. Wu Qin said that only purple-edged shells should be

used. Others mistook powdered pumice for this article, the names being confused with *haishi*, 海石.

The use of this powder covers many small and larger discomforts, but this is not the place to go into the medical use of this material.

Mica, *Yunmu*, 云母

Mica is one of the substances I did not expect to see in the samples from the Tang tombs. In the later Ming and Qing dynasties times, mica is sometimes added to paint to improve its quality by adding extra lustre, and possibly sometimes to bulk it out. In paintings on silk and paper one can recognize it by the thickness of the paint layer, and the specific lustre when the painting is exposed to a strong light source. After finding mica in several samples, a second inspection of the painted surface of the Yide piece with Que-towers convinced me of the presence of mica in the red parts of the towers. This observation becomes all the more clear when for only a few moments the special lighting is turned on. It is impossible to take samples from this part of the wall, so my visual observation is all I can offer here as evidence.



Photograph 3-21
Mica for painting.

There are many synonyms for mica or *Yunmu* in the *Materia Medica* [Read and Pak, entry 39, p 24]:

Yunmushi, 云母石[mica mineral]

Huochai, 火齐[fire alloy]

Meigui, 玫瑰[rugosa rose]

Yunjing, 云精[mica spirit]

Tangti, 螳螂[cicada antimony]

Qianpianshi, 千片石[thousand pieces mineral]

Mingwa, 明瓦[clear tiles]

Mengshi, 礞石[meng mineral]

Yinjingshi, 银精石[silver spirit mineral]

Yinxingshi, 银星石[silver star tiles]

Yunhua, 云华[cloud from Hua, name of a mountain in Shaanxi]

Yunzhu, 云珠[cloud pearl]

Yunye, 云液[cloud liquid]

Yunying, 云英[cloud shine]

Yunsha, 云砂[cloud sand]

Linshi, 磷石[phosphorus mineral]

To this day, there are several forms of *yunmu*;

Modern terms:

Yunmushi, (Mica), 云母石

Hongyunmu, (Lepololite), 红云母

Baiyunmu, (Muscovite), 白云母

Jinyunmu, (Phogopite), 金云母

Heyunmu, (Rubellan), 褐云母

It is very poor in quality. There are five or eight kinds of different coloured micas.

Yunmushi is feldspar.

Feldspar is also termed

Changshi, 长石, [long mineral]

Shiying, 石英, [mineral shine]

Cishiying, 瓷石英, [porcelain mineral shine]

Meigui 玫瑰 was used for *Huozhu*. It is a synonym for a ruby =

Hongbaoshi, 红宝石, [red gem mineral]

Huochai is synonym for lapis lazuli, *Liuli*, 琉璃。

Mengshi is mica, which is mixed with other minerals.

Yunmu is black mica – *biotite*.

Biotite is also called

Qiancengying, 千层瑛, [thousand layered gemstone]

Heihongmushi, 黑红母石, [black red mineral]

Talc is called *yunmu*, 云母 also *Yunmushi*, and 云母石。

Yunhua is *Phogopite*, mica of various colors, it is also called *Jinyunmu*, [金云母].

Yunzhu is *Lepololite*, mostly red, also termed *Yancengzhi*, 胭层纸

Hongyunmu, 红云母

Yunye is *Muscovite*, mostly of white or yellowish-white color, also termed, *baiyunmushi*, and 白云母石[white mica mineral]

Qiancengshi, 千层石[thousand layer mineral]

Jinjingshi, 金晶石[gold cristal mineral]

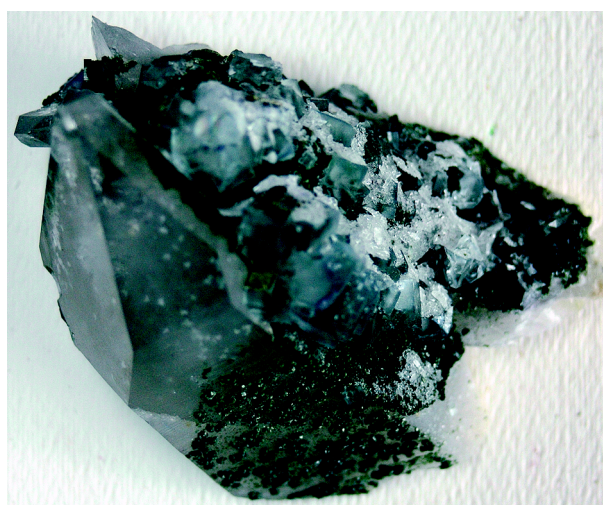
Yunying is mostly of blue color, and *Yunsha* is mostly of blue-yellow color.

Linshi is pure white in color.

Peking sample was white mica, muscovite $H_2(K.Na)Al_3(SiO_4)_3$.⁷⁶

I think this summary in the *Materia Medica* gives a clear indication of the difficulties involved in translation of any of the terms mentioned here: there is a lot of confusion in the interpretation of the various terms for and forms of mica. We can also see that in the same book the term *yunmushi* is used both for mica and for feldspar. *Yunmusha* is normally a term used for vermilion: a corruption of the word is easily made when the last character is misread, taking *shi* for *sha*, 石, 沙。

I would like to propose the use of mica as a carrier for vegetable dye and maybe for lac, although indicated by analysis, it is not yet fully proven, and requires further research.



Photograph 3-22

Mica specimen with fluorite, quartz and green mica from the Yaogangxian Mine in Hunan province, China.

⁷⁶ Note that this sample is by Read and Pak, they only give chemical terms in connection with samples.

Vegetable Dyes and other organic materials

The use of vegetable dyes is one of the least researched areas of painting technique in China. Although some textile experts and archaeologists have worked on this subject, its connection with painting is largely ignored. This section aims to bring forward vegetable dyes as genuine painting materials, and to this end I combine the agricultural knowledge from the fifth century farmers handbook (*Qimin yaoshu*) [Jia Sixie 1] with the paintings on which scientific methods prove a vegetable dye has been used. The 17th century *Chinese Technology in the Seventeenth Century* (*Tiangong kaiwu*) [Song 2], and the 20th century *Wang Xu and Textile Archaeology in China* [Zhao Feng] will be used as additional references in this chapter. Finally, yet crucially, I will use the evidence presented by the analysis of several samples from art works to show that these vegetable components are sometimes mixed with another vegetable dye or, even more surprisingly, with a mineral component. Examples of vegetable components are found in the samples; YD1, ZH2, ZH3, ZQX1, they are proposed one of the vegetable dyes that are described below.

The most remarkable dye used in ancient China is cinnabar, although it should not, strictly scientifically speaking, be described as "dyeing". The cinnabar is ground into a powder and combined with other materials to form a paste that is applied to the surface of the silk. To start with a mixture of minerals and vegetable dyes I refer to the work of the Chinese archeologist Wang Xu in the chapter 'The principle of dyeing' in *Wang Xu and Textile Archaeology in China* [Zhao Feng, p 62]. According to Wang, pressure dyeing, a method of impregnating silk with cinnabar, was being used by the Yin dynasty (14th - 11th century BC), and it may be even older. This method continued to be used till Han dynastic times, and is also known as daub dyeing. We can therefore safely say that use of the various dyes goes back to the dawn of the Chinese culture, since they have been identified on some very early artifacts, mostly textiles.

I would here like to discuss some vegetable dyes and painting materials, such as Indigo, Safflower, Earth Yellow and other vegetable-based dyes that are mentioned in early texts. Sometimes the exact nature of the substance can be obscured by changes in the usage of

terms or, at a later stage, by translations or interpretations of the term. The first example of this confusion of terms, in this case for economic gain, concerns the safflower.

Safflower, *honglanhua*, 红篮花

If you go to a market today in, for example, Xi'an, you will be surrounded by the very particular scent of the safflower. This is sold in bags with labels that correctly state its proper Chinese name, *honglanhua*, but also give the incorrect English appellation 'Saffron'. Although the safflower is also known as "false saffron", in reality the Chinese vender is preying on the tourist who believes they are buying the much more valuable true saffron.



Photograph 3-23

Safflower as sold on the Xi'an marketplace.

Safflower is indigenous to many regions of China, and the flowers are used in the rouge that women have used for centuries to give a blush to their cheeks. The cakes of safflower have another use in painting: it is probable that this started very early, but the first direct and undisputable connection to painters I have found so far is in the *Chinese Technology in the Seventeenth Century* (*Tiangong kaiwu*) [Song 2, p. 77]:

Nowadays in the Chi-ning area [in Shantung], however, it is made only from the dregs of safflower left over from the dye works and it is worth very little. The dried safflower dregs are called 'purple powder'; it is sometimes used as a color by artists, but dyers discard it as waste matter.

The method of farming safflower is described in the farmers handbook (*Qimin yaoshu*), [Jia Sixie 1, p. 364]:

Growing *Honglanhua*, 红蓝花, *Zhizi*, 梔子

For sowing, one must use the fertile fields. Sow them from the end of the second month until the start of the third month.

Sowing method: After it rains you must quickly plant them, either by overflowing and dispersing seeds, or by ploughing them under; both methods are the same as the hemp-growing method. In addition, there is the method of opening up the earth with a hoe and covering the seeds. The seeds and reeds are big and leave the reed easily.

When the flowers bloom, they must be picked every day in the cool of the day; if they are not picked they dry out. The picking must be complete. Leftovers must be put together. In the fifth month, when the seeds are ripe, split them, wet them and dry them. The seeds do not need to be soaked. In the fifth month you sow the last flowers. The remaining seeds from the early spring can be sowed until the fifth month, but when the new flowers are ripe and you collect the seeds, it is too late.

The ones picked in the middle of the seventh month are deep coloured and fresh and brilliant; they do not shed their colour for a long time, and are better than the ones sown in spring. The best fields around the capital grow, per hectare, a yearly crop of enough to dye 300 rolls of silk. One hectare produces 200 *Jiao*⁷⁷ of seed, which commands exactly the same price as hempseed; it can be used for axle grease and for candlesticks, and the tops can produce grain. 200 stone of grain, from a good field, is gained on top of the 300 rolls of silk.

One hectare of flowers on a day needs a 100 people to pick; with the labour of one family [ten people] indeed ten families are not sufficient for one [hectare].

However, if you harness a horse at the front, every sunset a hundred youngboys and girls will gather there, and when it comes to dividing the crop, it must be distributed evenly, and the average must be divided. Childless couples should also get their weight.

How to collect the flowers:

The crop must be pounded before cooking, and then sieved with water, put in a cotton bag and the yellow juice wrung out. Pound again with rice gruel, and wet it till it sours and then sieve it. Once more wring out the juice in a cotton bag: this way you get a red dye that does not fade.

⁷⁷ *Jiao* is a coin 1/10 of a *yuan*.

Wring till dry, put it in a vessel, cover it with a cloth, and when the cock crows, pound it again evenly, put it on a reed mat and dry it in the sun, and then form the product into cakes. For use, the cakes must not be too dry, and you must wet the flowers.



Photograph 3-24

Rouge prepared with glue, a traditional paint material sold in small boxes with a paper wrapping, printed with red characters.

Method of making rouge;

Prepare and roast plant ashes, *li*-weeds [goosefeet], bean-pulses, and *hao* [*artemisia*] for making ashes. If you do not have these, any form of plant ashes will do.

Take the soup and soak out the clear juice. The first juice pure and thick, is too strong and will break the flowers, and is not used for the rouge, it can only dye cloth. However, the third rinsing of the rubbed flowers, blended, makes a good colour.

Rubbed flowers: do this ten times over to completely exhaust its power. The cotton bag gives out a pure juice: put it in a porcelain bowl. Take the juice of two or three pomegranates, split the kernels, pound them, mix this with some sour rice gruel, squeeze it through a cotton bag, and mix it with the flower juice. If you do not have pomegranate you can use good vinegar with rice gruel. If you do not use vinegar, sour clear rice gruel can be used alone. Put in some white rice flour, about the quantity the size of a date: more flour makes it whiter. Stir it thoroughly with a clean non-greasy bamboo chop stick. Cover it at night, and filter out the clear juice until it is finished. Put the remains in a cotton bag and hang it out to dry. On the day when it is half dry, roll it into small balls, half the size of a hemp seed, and dry it in the shade: then it is ready.

In the *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* [Song 2, p 73], several examples are given of the use of safflower in the dyeing of cloth, from crimson to

lotus pink, peach blossom pink, silver pink and pale clear pink. There is also mention of a trade secret, and of the way one can remove the color from the silk with an aqueous solution of caustic soda or rice stalk ash. The advice is given to store this solution in green lentil flour, enabling it to be used again afterwards without any loss. I presume the lentil flour serves as a safe dry environment for temporary storage of the substance.

Indigo, *lan*, 藍, *huaqing*, 花青

Walking along the street anywhere in present-day China, in major cities and even more in the countryside, one can still see the presence of indigo all around. This vegetable dye has a long track record in the life of the people and history of the area. Its first and primary utilization still lies in the clothing industry, as has been so for many centuries, with a definite peak and an unprecedented monopoly in the days of Mao when everybody had to wear a similar suit of indigo-blue material. The images of this are still on the retinas of the generation that lived through these days. The fact that the population of the western world, at roughly at the same time, was walking around mostly in jeans of different shades of the same indigo blue could have made indigo the largest dye crop in the world. However, these days most indigo, even in China, is produced chemically.



Photograph 3-25

Indigo of the first quality mixed with clear glue. This is prepared indigo, a traditional paint material sold in small boxes with a paper wrapping, printed with red characters.

The plants

The use of indigo is indigenous to large parts of China, which is proven by the earliest written records such as the *Erya* and the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1]. Several different species are used to extract the deep blue-coloured dye we call indigo. The Chinese word for blue, *lan*, is synonymous with the word for indigo, which shows the strong

connection between the plant and the colour. The colour was first used for dyeing cloth, and later for painting, as will be elaborated below.

In his translation *Chinese Technology in the Seventeenth Century* (*Tiangong gaiwu*), E-tu Zensun identifies five different plants by name, all of which produce indigo: *Isiatis tinctoria*; *Polygonum tinctorum*; *Strobilanthes flaccidifolius*; and *Indigofera Kiangsu*. They are all grown from seed; and a recent [meaning seventeenth century] variety, *Amarantacea tinctorium* which is commonly called 'Pigweed indigo'. The most important one is the *Polygonum Tinctorium*, found in central, northern and north-eastern China. [Song 2, p. 75] In the book by J. Needham and Tien Tsien-hsuei, 'Science and Civilization in China, volume VI, Chemistry and chemical technology. Part 1, Paper and Printing', p 158, we read:

蓝

We may here remark in passing that the indigo shown, *Polygonum tinctorium*, was the ancient and indigenous blue dye-plant of China, the father and mother of those million of good blue garments that those who have lived in China know so well.

青黛，木蓝

The true indigo, *Indigofera tinctoria*, a tropical or subtropical plant, passed from India to Persia about the 6th century, became known to China during the Tang dynasty as *qing dai*, or *mulan*, and was afterwards cultivated in the southern provinces.

松蓝

Our English woad *Isiatis tinctoria*, called *songlan*, is also found in China, but was probably a much later introduction, arriving just in time for its mention by Li Shizhen at the end of the 16th century.

Cultivation

*Simin yueling*⁷⁸ [Cui, p 26], says that 'in the third month, when the elm seeds fall' you must plant the indigo. This line solves one of the problems that still occurs with the indication of time in the farmers handbook (*Qimin yaoshu*) [see below]: it speaks of the first month, but this still fails to give us a fixed date, since in the Chinese calendar the start of the new year and consequently the start of the first month can vary by many days. For the farmer, the terms

⁷⁸ *Simin yueling*, Cui Shi: a book from the second century CE written by Cui Shi (145-167), the present text of this book is a reconstruction made by the use of quotations in two later sources: the *Qimin yaoshu* [see Bibliography] and the *Yutu baodian*, written by Du Taiping in the Northern Zhou dynasty (557-581).

first month, second month and so on give no reliable time schedule for sowing and planting, but since the sentence '...when the elm seeds fall,.. ' is quoted from *Simin yueling*, this makes a connection with the seasonal changes of nature, providing the farmer with a real-time term he can use. On p 43 of the *Simin yueling* [Cui], it says that in fifth month one must grow indigo in the paddy-fields, and later, on p 51, it says that in the sixth month you can grow winter-indigo (*donglan*, 冬藍). Another interesting fact in the *Simin yueling* [Cui] is found on p 2, where the *Qing* 青 is ready for gathering, and on p 51 it says that one can dye with the *Qing*. The farmers handbook (*Qimin yaoshu*) also gives this same statement in the section of miscellaneous information with no direct connection to sowing crops, which starts on p 226. [Jia Sixie 1] *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)*[Song 2, p 75] explains that one should prepare the soil in spring by burning and in this way fertilizing it; holes are then made at a slight slant and the indigo stems saved from the year before are planted in these holes, to grow effortlessly into new plants. Young shoots appear in late spring, in the sixth month fruits are formed, and in the seventh month, (early August to early September) the plants can be cut and harvested.

Extraction Methods

The *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* says that the method of extracting *indicum*⁷⁹ with hot water is described in the farmers handbook (*Qimin yaoshu*), and that the yield is up to 80 or 85 % with this method.

My translation is taken directly from the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 374] entry on Indigo:

For growing *lan*, indigo fields of the best quality are required. They must be ploughed very finely three times. During the third month soak the seeds to make the shoots spring up, and then sow them in sow beds. Prepare the beds when it rains, just as with sunflowers. When the indigo has three leaves, water them every morning and night. Weed them to keep the beds clean. In the middle of the fifth month after fresh rain, when it is wet, plough and sow, and plant the seedlings. (In the small Xia calendar it says: the fifth month makes the freshest shoots of *lan*.)

⁷⁹ *Indicum* is the actual colourant in the indigo plants; in modern times it is often made artificially.

Three stems form one bundle and the distance between them must be eight *cun*⁸⁰.
(Plant with everybody together and do not let the earth dry out.)

When the back of the leaves whiten, you must quickly hoe them. (Moisten them in time, as if you not water them when the back turns white they will dry out.) Five times is the best.

During the seventh month make a hole, making sure it holds more than a hundred stems if you bind them. Take grain, crushing it into a muddy paste, until it is five *cun* deep, and cover the four walls with straw matting. Cut the *Polygonum*, and set it up in the hole, water it, and put on wood and stones to press it down until it is submerged. If it is warm, it ripens overnight, and if it is cold after one more night, drain the liquids from the fibre, and put the juice in an earthenware jar. In a ten-stone earthenware jar put one and a half *dou* of lime, mix it by hand for the time one meal takes. When it clarifies, drain out the water, make another small hole, store the indigo *landian* in the hole, wait for the gruel to get strong, again take it out and put in a earthenware jar to process, the indigo is then ready.

Growing ten *mou*⁸¹ of *lan* is equal in terms of profit to growing a hundred *mou* of millet. If you can dye yourself, the profit is doubled once more. Cui Shi says: When the elm seeds are in season one can grow *lan*; in the fifth month one can harvest the *lan*; in the sixth month one can grow *donglan* [冬藍, winter *lan*].

(*donglan* is *mulan* [木藍, wood *lan*]; in the eighth month it can be used to dye.)

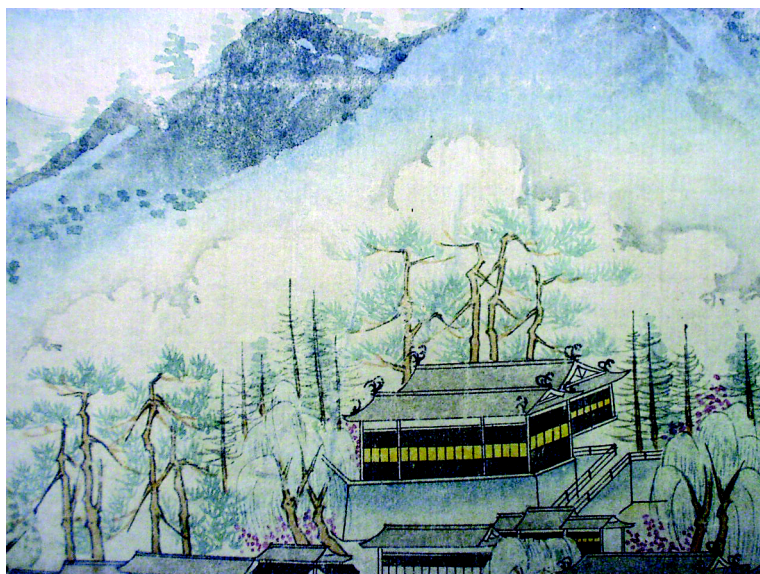
In the *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* [Song 2, p 76] we find a second method:

Large quantities of indigo are placed in a pit, and for smaller amounts vats or barrels are used. This is soaked for seven days to extract the juice. Lime is added on a daily basis, five pints for each *tan*⁸² of this solution; this is stirred many times a day for oxidation. The indigo will settle on the bottom.

⁸⁰ *Cun*: unite of length; 3 *cun* = 10 cm.

⁸¹ *Mou*: unite of area measure; 15 *mou* = 1 hectare.

⁸² *Tan*: measure of fluids.



Photograph 3-26

Indigo in the blue trees of the scroll 'Panorama of Hang Zhou on West Lake'; Acc. No. F1911. 209, Freer Gallery of Art.

Early traces of indigo in painting

In the murals I have not found indigo, but because of its importance as a vegetable dye I give examples of scientifically confirmed traces of indigo. In the collection of the Freer gallery in Washington there are some examples of the use of indigo in paintings; some on silk and others on paper. Some are pure indigo but there are also several instances of mixtures with ink or other organic dyes: organic meaning from a living source, probably insect dye.⁸³

Indigo is present in 'Panorama of Hang Zhou on the West Lake.' [Acc no F 1911.209] [see Photograph 3-26] This painting from the Ming dynasty (1368- 1644) is a hand scroll on paper, measuring 33.3 cm. by 1849.8 cm, and is in the collection of the Freer Gallery of Art. The label reads: 'Color. Inscription on mount at the right. Ms. And 3 seals on mount at the left.' In this long hand scroll, indigo is present in the water, sky, mountains and bamboo. According to the SCIRM-archive, indigo is confirmed by UV/vis reflectance and by XRF. I have observed the various shades of green in parts that are possibly a mixture of indigo with some kind of yellow. For the yellow there are several options to consider: in my opinion safflower, the yellow made of the *huai* flower, and yellow made from *dihuang* are among the candidates. There are also yellow parts on the windows that are confirmed by X-Ray

⁸³ The FORS analysis is done by Jennifer Giaccari and the results were discussed in private communication, for which I am deeply grateful. FORS: fiber optics reflectance spectroscopy. see for specifics [Leona, M. and Winter, J.]

Fluorescence to be an 'iron earth yellow'. I think this is most likely to be some kind of ochre. Further description of the early traces of indigo in painting are described below. In this painting F1911.209 the blues and greens all appear to be indigo based. (see photograph 3-26)

The painting F1915.16 contains many pigments, both inorganic and organic. Blue-grey of horses appears to be an indigo and Chinese ink mixture. (see photograph 3-27) The blue of the clothing and saddles appears to be azurite. The dark purple clothing of the Mongols is a mixture of indigo and an organic red insect dye. The purple-pink color of the saddle accents and some clothing appears to be the insect dye alone.

This painting, in the style of Han Kan as the inscription says, is part of a long line of such paintings, similar to the Li Gonglin's masterpiece, 'Five tribute horses', which is datable to 1090.

Photograph 3-27, below,

Section of the scroll painting 'Mongols bringing a tribute of horses'; The design is attributed to Han Gan (ca. 715- after 781) and the painting is dated 1368-1644; colour and gold on silk; 192.8 x 31.0 cm.; Acc. No. F1915.16, Freer Gallery of Art.





Detail of Photograph 3-28

Photograph 3-28, scroll painting 'A Tartar horseman and a rolling horse'; 14th-15th century; ink and colour on silk panel; 120.6 x 46.3 cm.; Acc. No. F1916.526, Freer Gallery of Art. The blue details of the saddle and blue clothing appear to be indigo.



Earth Yellow, *Dihuang*, 地黄

By the fifth century CE, the root of a figwort plant was already in use as a yellow dye to colour silk, as is clear from the following description in the the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p. 239]:

In the eighth month, in the *shutui*-period (decline of heat), the children go to study, as in the first month. When the cold wind announces the cold, you take out the rain-proof cloth, and dye the bright colours (*caise*, 彩色).

[This is an antonym for dark colours (*zase*, 雜色, of which imperial yellow is one.)]

(Note 7: *Caise*: old-fashioned yellow, *chi* red and other such bright colours, while relatively dark colors are called *zase*, dark colours.)

(Note 8: *Dihuang*, earth yellow, *rehmannia glutinosa*: this is *xuanshenliao*, 玄参料, the root of the Zhejiang figwort, a perennial plant. The root form and the nature of the stem pulp is fleshy, the colour is yellow, and it produces an aqueous solution to dye yellow.)

The Hedong method of dyeing imperial yellow:

Beat the root of *dihuang*, earth yellow until it is ripe, mix it with ash juice, mix this evenly, take out the juice, and put it in another bowl. Pound the sediments again, until it is ripe, once more mix it with ash juice, of the same consistency as thin rice gruel: put it in a *buyufu*, a non- changing cauldron⁸⁴, and prepare fresh silk. Turn it many times to make it even, lift it to see if it has water-filled pockets, and then the silk is ready.

Take it out of the water, and put it in a basin. Find the beginning, unravel, and stretch it to its fullest length. Shortly afterwards wring it, and clean it by wiping out the sediments. Dry it in the sun. Take another silk for the filtered pure white juice, heat it slightly and take it out, put it in a bowl to dye, unroll and stretch it quickly to make it even. When the sap is cold, wring it out; dry it in the sun, and then it is ready. The way to make a non- changing cauldron is described in the brewing section. In general three *sheng*⁸⁵ of earth yellow can dye one roll of imperial yellow. The more earth yellow,

the better. Oak brushwood, mulberry firewood, straw ash and other such material, all can be used.



Photograph 3-29,
Dihuang, specimen as still sold by Chinese pharmacists.

A question for conservation studies

In my view the dye material from the root of the *dihuang* needs further investigation and analysis, as will be explained in the following argument.

⁸⁴ The entry on brewing of the book has a discription of this tool, I did not include it in the translation.

⁸⁵ *Sheng* unite of fluid equal to 1 litre.

Maarten van Bommel has done HPLC (High Performance Liquid Chromatography) research on Chinese textiles from archeological finds dating to the third and fourth century BC in the collection of the Abegg Stiftung. Some red dyes are defined as insect dye from the insect *Porphyrophora coccid*. The yellow dyestuff is not positively identified. I suggest that this could be *dihuang*, and plan to examine this further in the near future. At this point it is not known if this might also have been used for the conservation of paper and silk against pests, something for which orpiment, as described before, is known to have been used.

The study by Peter J. Gibbs and Kenneth R. Seddon, *Berberine and Huangbo: Ancient Colorants and Dyes*, British Library Studies in Conservation Science 2, 1998 show that the interpretation by Joseph Needham's series [Needham, vol 5, part 1, p 74-75] of *huangbo* (*Phellodendron amurense*) as the only source for paper yellow dyes in ancient China is wrong. Their study does show conflicting evidence for the use of *Phellodendron amurense*:⁸⁶

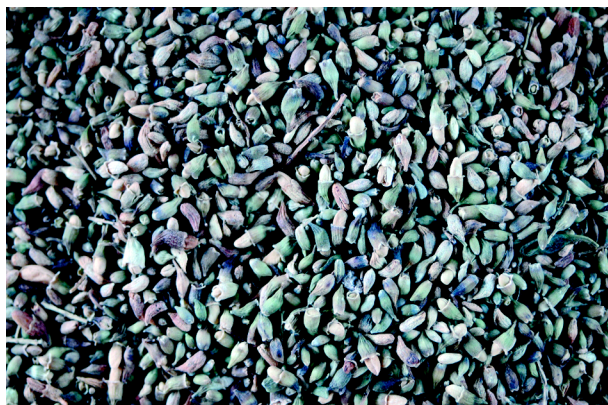
Examination of tiny fragments (3x1 mm) of twenty-five ancient papers contemporary with the Dunhuang *Diamond Sutra* [revealed the presence of berberine on twenty-one samples, palmatine on eighteen samples and jatrorrhizine on five samples. In no instance was palmatine or jatrorrhizine detected when berberine was not also found. The unusual high relative abundance of jatrorrhizine detected on two of the samples analyzed was the first suggestion that a dye other than *huangbo* may have been used to color ancient Chinese papers.

In my opinion there are at least two more yellow dyes involved, or rather one dye and one mineral. Both are recorded in the farmers handbook (*Qimin yaoshu*): one is *dihuang*, that is used for dyeing textiles, and the other, as described above in the mineral section, is orpiment, a yellow colourant used to protect paper from insects and other pests.

There is a different use of this material recorded in *Chinese Technology in the Seventeenth Century* (*Tiangong kaiwu*)[Song 2, p. 75]:

Ivory color is obtained by dyeing slightly in (an aqueous solution of) yellow earth, *huangtu*, 黄土。

⁸⁶ Gibbs and Seddon, 1998, p 53

Flower Yellow, *Huai*, 槐花

Photograph 3-30

Huai flower: the unopened flower buds are used to make a light green dye.

The *huai* flower grows on the *huai* tree, also known as *Saphora Japonica*. The tree only blooms after at least 10 years. In the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 350], we find the method of growing *Huai* trees:

The *Huai*

Erya: "Shougonghuai 守宫槐, the leafs of the flower open at night." The comment is: "The leaves of the *huai* flower open at night and close during the day; its name: shougong 守宫.

When the *huai* is ready [this means: at the stage of still unopened flower buds] collect many of them; break them of; dry them in the sun several times; and do not allow insects to develop. In the fifth month, during the ten days before the Summer solstice, soak them in water, just as with the hempseed method. The shoots will come out in six or seven days. At the time it rains and the hemp is sown, they can be sown together with the hempseed. In the same year, plant the *huai* with the hemp stalks as guides. When the hemp is ripe, cut it, and leave the *huai* to remain. The *huai* is long and thin, and it can not stand alone or with other guide poles; it must be bound with a rope. in winter when there is wind and rain, bind up the shoots; if they are not straight the bark bruises, and this leaves scars. The next year prepare fertile ground, once again plant hempseed between the *huai*. The *huai* shall grow longer. In the first month of the third year leave the trees alone, as they stand alone with straight branches; a thousand will look just as one. this is called 'Bi planted between hemp, grows straight unsupported.' If they are planted out in the course of time, the bended trees would slowly grow crooked. They can be planted in a garden. In a good garden, but if they are not first moved, you can not plough.

Chinese Technology in the Seventeenth Century (Tiangong kaiwu) [Song 2, p 74] tells us more about a green colour that dye from *huai* flower buds produces in combination with indigo:

Dark green. Dyed first with the juice of boiled *huai* flower and next soaked in indigo solution. Alum is used (as a mordant) for both the light and darker shades of this color.
Light green. This is slightly dyed with the *huai* flower (liquid) and soaked in green vitriol (solution).

Glue and Mordant

As we have seen in the text above - for example in the preparation of rouge and indigo- a mordant or a glue is often needed for the production of vegetable dyes. The glue is often used not exclusively for painting, but for repairs of all sorts of household tools and garments. Every farmer or family used to make their own glue, and in some parts of China this is still done. A very clear description of the preparation process is found in the farmers handbook (*Qimin yaoshu*). One of the mordants already mentioned above is plant ash: the preparation of this is also described in the farmers handbook (*Qimin yaoshu*). Glue and plant ash both are translated below. Alum is also used as a mordant.

Chinese Technology in the Seventeenth Century (Tiangong kaiwu) [Song 2, p. 59]:

A-Jiao

The river Qishui in Lixia runs largely underground. In Dong-a, the water of this river is used to boil glue, which is called *a-jiao* [a-glue]. Shen Gua says it is used as a medicine against all sorts of congestion in the body.

[Shen Gua, scroll 2, section 62, p 44]:

A jiao, 啊胶.

People used to say that the Qishui runs partly underground. Nowadays in Lixia everywhere you dig a hole water flows, and that is the Qishui running underground. This Qishui also runs through Dong'a; the water is cooked as glue, this is called ah-jiao, ah-glue; if one shakes it with muddy water it becomes clear. If used by people it lowers the diaphragm, dissolves phlegm, and stops vomiting. All of this is due to the nature of the Qishui, hurrying down from light and heavy; it has been said that it cures constipation and works against diseases. At present no recipes provide the reason for this.



Photograph 3-31

Dong-A glue, specimen as still sold by Chinese pharmacists.

Bernard E. Read in his translation of the *Materia Medica (Bencao cangmu)* ‘Animal drugs no 335’, says that *A-Jiao*, ‘A- glue’ is made of ass and cow. [Read3] After comparing the texts I conclude the description is based on the farmers handbook (*Qimin yaoshu*) text fragment translated below, and not on the above text by Shen Gua.

The normal practical method of making glue stems from the early source the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 679]:

Method for cooking glue:

Cook the glue in the second month, the third month, the ninth month, and the tenth month. The other months are unsuitable. In summer it will not congeal, and you can not make cakes; in winter ice will be formed and the glue will not stick.

Buffalo-skin, water buffalo-skin, pig-skin are the best; ass-, horse-, camel-, and mule-skin come second. The latter glue is strong, comparable with the first, except that ass and horse skin has too much hair, so the quantity of glue is too small, and firewood is spilled. Old leather garments and shoe soles and all sorts of hide, boot soles, broken saddle parts and belts can be used, but it must be untreated leather: no matter how old it is, if it is not rotten, it can all be boiled. From fresh hides the glue produced is fresh and clear, and although old pieces are suitable, they are not as good as the new ones. Greasy and tanned hides can not be used. For example in a pig iron [cauldron], that is softend by cooking, and has never been casted, the pulp will not set. Only use an old

cauldron that is large and does not change. A new cauldron will cause the hides to burn at the bottom, a small cauldron will spill charcoal, and if the non-changing-cauldron is new it will cause the glue to turn black.

Method:

In a pit to the side of the spring, soak the hide for four or five days, until it is full of liquid. Use clean water to wash it; it must not be muddy. Cut into pieces, and cook it in the cauldron: you do not have to get rid of the hair. Getting rid of the hair is a waste of work, and does not improve the glue. Bring the water to the boil; salty and bitter water will make the glue better. Work it at length with a wooden ladle not letting the bottom boil; the ladle head will become sharp from time after time scratching the bottom. If the ladle does not become sharpened, the bottom has not been touched, and if the bottom is not worked it will burn. Burned glue is bad, therefore you must work it many times. If there is not enough water, more must be added, which often causes a raging overflow. For one day and one night, do not interrupt the fire. When the hides are ready, take the ladle out of the juice and see if a pearl forms on the end, then you have sticking power, and the glue is ready. If the fire goes on any longer, the glue will burn. Take a clean bowl, place it on the furnace board, to filter put the rice-bed on a bowl, spread straw⁸⁷ on the rice-bed, and with a big cup scoop up the glue water and drain the leftovers through the straw, filtering out the dregs. When draining do not stop the fire. If the fire stops the glue may settle at the bottom, and cannot be drained. When the clean, cooked juice is finished, add more water to boil; stir like the first time. Cook again to extract more. If the hide comes to an end, the cooked glue burns black, and has no sticking quality left, so now throw it out.

Fill the bowl with glue, carry it to an empty quiet spot in a room, and let it congeal without a cover. If you cover it the damp will condensate and the glue will turn. On a cold day, turn the bowl over on a mat and peel off the congealed glue. With thin thread that is moistened by mouth it can be cut; with regard to the pieces on the bottom that are not good, do not use them, but cut off a small strip, and afterwards cut it into squares, smaller and smaller, and from the small strips you form cakes. Only the smallest strips are good, otherwise you can not dry them properly, also the colour of amber is the best; but if it is stiff and thick it is hard to roast, and if it looks dark, these both pose a gluing problem. The bottom layer of the bowl is called *benjiao*, root glue, which is used in wagon building; the top layer in the bowl is *jiaoqing*, clear glue, which

⁸⁷ The straw spread on a rack [the rice-bed] functions as a sieve.

can be used for anything. The skin of the top layer is like the skin on porridge, and the glue above the middle has the best sticking power.

First use the platform in the room, using three kinds of drying frames, hare, dog and rat. Put the glue cakes on the lowest frame on a cloth, the upper two will provide shade and protect against frost and dew. The glue cakes are only congealed and are not completely dry: if they see sun they will sweat; frost, dew, wetting and dripping makes it hard to dry them again. From rising in the morning until dinner time you must turn the upper frame, to let the glue see sun; on frosty mornings with cold air, if it does not clear up; although the frost and dew will wet them, the sun will dry them again. After dinner the frame must be put back in the shade. If it rains, put them under the roof: for this you do not need a frame. After 4 or 5 of days drying time, pierce and bind the glue cakes and hang them to dry in the sun.

When they are completely dry, then you must hang them in the inner-room in paper baskets. This protects them against greenflies and dust. In the summer they seem to soften, but until the autumn festival in the eight month, they will dry in the sun and will stay flat.

Fish glue, *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* [Song 2, p. 262]:

Glue is made from the bladders and intestines of fish. The boiling (of the bladders and intestines in water for manufacturing glue) is largely carried out at Ning-kuo commandery (in modern Anhui province). In Chekiang, where the *Seiaena schlegeli* fish is obtained from the East sea, the bladder that remains from the making of dried salt fish is converted into glue, which is stronger than any kind of metal or iron. The northern barbarians also manufacture a glue by boiling sea-fish bladders (in water). This glue is as strong as the Chinese products, though it differs from the latter in (chemical and physical) properties.



Photograph 3-32

Fish glue, specimen from Xi'an China.

Plant ash, *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* [Song 2, p. 59]:

The silk in the woven cloth is still in its raw state, which will become 'supple' after boiling. First, it is boiled with an aqueous solution of rice-stalk ashes and then steeped overnight in a solution of lard soap.

In the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p. 234], we find the method to prepare a mordant for dyeing textile:

In the sixth month ... you must burn plants to dye *qing*, 青 natural colours, and various purple colours.

Note 28;

Burning plant ash: woven silk and hemp do not take the dyes easily: you need a mordant to fix the colour to the threads. Vegetable ash holds potassium carbonate, (*tansuanjia* 碳酸钾) dissolved in water it can be used as a mordant for vegetable dyes, to fix the colour. The ancients, from very early times onwards used plant ash for dyeing.

秆

Gan: purple: a red colour is part of the *qing* commonly called *hongqing* 红青 and *tianqing* 天青, natural colours.

Chinese plums

In *Chinese Technology in the Seventeenth Century (Tiangong kaiwu)* [Song 2, p. 59] we find that sometimes chinese plums are useful for de-gumming the silk before dyeing:

Some people use (aqueous extract of) smoked Chinese plums (as a de-gumming agent), and the result is a slightly duller lustre.

As we have discussed above, Shen Gua is convinced that *Xuan* is a reddish-black-colour, looking a lot like the feathers of a swallow: a deep purple colour, called black-purple, and it is so dark that the black and the purple are indistinguishable. The twentieth century experiments of the archeologist Wang Xu with the murex shell may be drawn into this debate on purple. [Zhao Feng p 98] Wang is convinced that the Chinese knew the way to extract purple from the indigenous species of murex shell. Other purple and black paints are

scattered through the sources, although none is very precise: at best they give an indication of possibilities for further research.

Gum and resin

Gums derive from various trees, for example peach gum. Peach gum is not a good glue for painting: I was warned by several painters never to use it, because of its easy solubility in water. Peach gum is a resin from peach-trees, and it is used precisely because of the quality of its solubility in water. The general assumption is that the resin can be removed with relatively little damage to the surface. This assumption, based on the 'known' fact that the murals' original paint layer is not soluble in water, has turned out to be a very dire mistake in some cases. The solubility of the peach-gum is exactly what causes problems in the case of a water-soluble or permeable painting colour. In conservation, however, it plays an important role, which has already been described in chapter 1.

Pear, and more specifically the birch leaf pear, is mentioned in several places as a specific colorant. For example in the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 346] we find:

Tang 棠, birch leaf pear,

To grow *tang*, the birch leaf pear.

Erya: *du* 杜 is the *gantang* 甘棠. *Gaopu* comment: the present-day *duli* 杜梨.

I [Jia Sixie] think that: among the present-day *tang* there are those that dye *jiang* 绛, big red, and others that only dye *tuzi* 土紫, earth purple; the *du* 杜 is completely different. In reality, there are three sorts that are all different.

Note 2

.... I think that with regard to pearjuice (*tangliye* 棠梨叶) there are many different sorts and many kinds and types that can dye a red or a purple colour. Red and purple dyes originate from the integral type of purple color, while others may be darker or lighter, but are in reality still the same as *tangli*....

... At the time when the *tang* is ready, you must pick them for planting. If you do not, in the spring month you can move the saplings.

Note 3

If you do not relocate the saplings in springtime you can just take the naturally grown saplings and replant them. At the beginning of the eighth month, on a clear day, you

must pick the leaves and spread them out thinly, dry them in the sun until they are dry, and this can be used to dye 'big red'. You must wait for a clear day, pick just a little, and dry them; then you can pick again. It must be harvested immediately: if it rains it will become damp, and if it is damp, you cannot create deep red....

When the trees are fully grown, the yearly yield dyes one roll of silk. You can grow more: then the profit exceeds that of the mulberry.

Confusion of terms

In China, there are many confusing terms; for example in the 11th century, Shen Gua says *men* 璚 is the name of a colour, and it is not, as the people of his time think, the yellow-colored jade in itself:

Men is an ochre colour that looks like the colour of panicle-millet. *Men* is somewhere between red and yellow, and like yellow earth [ochre], it is shiny and sparkling.

According to Shen Gua, their mistake is due to the radical⁸⁸ *yu* 玉 in front of the character.

Shellac, *Zikuang*, 紫矿

Zikuang is a notoriously difficult term in this aspect; it falls under the category of minerals in the Chinese system, although the explanation often correctly states its true animal or vegetable nature. Bernard E. Read in his translation of the *Bencao cangmu*, Chinese *Materia Medica*, [Read 3, p 39] says:

It was originally included in the Ben Cao's monograph upon dragon's blood, it is now separated from the botanical group.

Li Shichen:....., this substance is purple in color with an ore-like texture. When broken open it is red, hence the name. In his time, the foreign countries in the south collected it attached to the broken branches of the trees and so it was called *zigeng* 紫梗, the purple branches.

.....

According to Wu Lu by Chang Po in the country of Chui Chen Yi Feng, there is a red-colored earth-like glue. When people see this earth, they know it contains ants, so they

⁸⁸ Radical: a part of a character.

plow up the ground and plant branches of the trees and the ants climb up and form the varnish, which solidifies like the eggs of the praying-mantis cocoons. People break off the varnish and use it to dye their cloth a true red color. It is called *yi qi chi xu*, 蚁漆赤序, ant varnished red cloth. This is lac. Dragon's blood is the resin of a tree and is found in the botanical section.



Photograph 3-33

Stick lac specimen from Indonesia; courtesy of Kremer Pigmente, Germany.

Zigeng, 紫梗

In the Chinese *Materia Medica*, Vegetable Kingdom on p 489 [Stuart] we find:

Gum-lac –

紫矿, *zikuang*

赤脚, *chijiao*

紫梗, *zigeng*

This is produced by the *Coccus lacca* on a species of *Erythrina*. It is given in the Pentsao [*Bencao gangmu*] under insect products, and will not be further mentioned here.

The fabrication of brushes and ink

The farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 683] provides us with a description of the way brushes and ink are made:

The brush method

The Wei Zhongjiang brush-method (*bifang* 笔方) says:

First comb the finest hare's hair with an iron comb, and secondly the *qing* 青 hair of the goat, take out the dirty hairs, and cover them so they will not curl and tangle. When the *ru* 茹 is over, each hair is separated from the next. (in the *ru* 茹 process one uses ones mouth to line up the tops of the hairs.) With all of them, use the back of the comb to pat them forcefully, putting the sharp tops of the hair in line. The roots have to be lined up one by one: by any means you must regulate and trim them flat and well, lining the hare hair with the goat hair, and drawing the goat hair about 2 *fen* back from the hare hair. Only then combine the rows and roll them together until they are totally round. Finish this forcefully. Take the straight goat hairs cut in the middle, and use them to cover the core. (note 9: the goat hair is the inner most core, while the hare hair is the second layer, so this last sentence indicates a third layer) It is now called the *bizhu* 笔住, brush column or the *mochi* 墨池, 'ink pool' or the *chengmo* 承墨, 'contains ink'. Again with the hare hair, cover the outside, [this is the fourth layer] as with the *chu* method, to make the core straight. Make it flat and even, press it severely in the tube, and determine the depth according to the hair length: ideally smaller rather than larger. These are the essentials of brush making.

Ink, *mo*, 墨, *moshui*, 墨水

Ink is a well-known material in Chinese painting that is made from carbon and glue. The carbon mainly comes from soot such as lamp soot, which is made by burning vegetable oils, or soot by burning pine wood. The oils used are tong oil, hemp seed oil, rapeseed oil and soybean oil, all come under the category of vegetable dyes.

The most commonly used black color is ink made from soot, as we can see in the farmers handbook (*Qimin yaoshu*) [Jia Sixie 1, p 683] in the recipe for the preparation of ink:

The ink method

Take good unmixed soot, pound it until ripe, take a fine silk sieve--- and sieve out the straw dust and sand, dust and dirt into a large earthenware jar; do this until it is very fine. Do not sieve it in the open air because it will fly away; this is unavoidable, so be careful. The ink left after sieving is one *jin*: take five *liang* of fine glue, soak it (to the core) with the skin and juice of the Chinese beech. This is the bark of the Jiangnan *fanji* tree, the bark colors the water green, solves glue, and deepens the ink color. Take the seeds from a pomegranate--wich produces yellow-- and add five seeds; you can also

add two *liang* of *zhubiao*, vermilion, and one *liang* of musk separately, and finely sieve it until blended. When it is dry and no longer damp, put it into a mortar, grind it thirty thousand times: the more you grind it the better. Ink cannot be made in the second and ninth month: when it is it goes bad and smells: when it is cold it is hard to dry the hot paste, and if a draught touches it it will turn. It is important not to make more than one or two *liang*. This is all there is to be said about ink as such: one would rather use less than more.

The kind of soot is not mentioned in this piece, and over the centuries a variety of soots have been put forward by different painters and calligraphers. Pine soot seems to be most used and valued through the ages.

At a later time, Shen Gua envisions a golden future for the ink made from *shiyou*, crude oil: a cheap and readily available source of material to burn for the soot as a basis for ink.

Oil, Nafta, *Shiyou*, 石油

In the Fu and Jian area stone-oil is found. The old books mention that in Gaonuxian fatty water is produced. Burning the oil produces a very thick fatty smoke, which leaves the tents black with soot. Shen Gua thought this might be useful, so he collected the soot to produce ink. He says it is as black and shiny as lacquer, superior to *song*-ink, pine-soot ink, and predicts that it will be used on a grand scale in the future. He gives it the name *Fuchuan shiye*. Since there is an abundance of this stone-oil emanating from the earth, he says, it cannot run out like the pine trees. By the 11th century, the pines in Ji and Lu were already much diminished in number, and places as far away as Taihang, Jingxi and Jingnan had bald mountain slopes. Soot-burners, he said, should know about this *shiyou*, and use it to their advantage. [Shen Gua, scroll 24, section 1, p 170]

