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DEPARTMENT OF SCIENCE
MINISTRY OF INDUSTRIES
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STUDIES OF PRECIOUS STONES IN SIAM

(With 4 Plates and 3 Drawings)

By

ULRICH GUHLER

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FOREWORD

This Bulletin which was intended to be a record of scientific research and investigation in Siam first appeared in 1937 and was known as the Siam Science Bulletin. In 1939 by the act of the National Assembly the name of Siam was officially changed into Thailand, the name of this Bulletin was accordingly changed into the Thai Science Bulletin. Since, however, Thailand has now resumed its original name of Siam, this Bulletin from now on, will be known by its old name.

At first the publication of this Bulletin was irregular but later it was published quarterly. Due to the war, however, publication was suspended temporarily and it is now intended to resume publication which will at first be irregular until such a time when it can be published quarterly as of old.

It is sincerely hoped that this Bulletin will fulfill its purpose in promoting foreign interest in the progress of science in Siam.

The Editor.

Studies of Precious Stones in Siam

(With 4 Plates and 3 Drawings)

BY

ULRICH GUHLER.

Introduction

Since time immemorial precious stones have exercised a particular and strange fascination upon mankind. It is not only the inborn tendency of men to acquire riches, it is in many cases not only the natural wish to possess beautiful things, but it is in my opinion also the mystery that surrounds each gem, the mystery of its origin, when nature made it, and the mystery of its fate and travels through so many hands before it reached its present owner. Gold and other precious metals stimulate the imagination of many, particularly of those who have none. But gold, that alluring yellow metal, has been somewhat degraded to a commercial commodity, its price is quoted on official and unofficial exchanges, it serves as basis for the currencies of the world and is traded like any other article of a certain fixed and constant quality. On the other hand precious stones are different from gold. Like men, there are no two gems entirely identical, there is no fixed value for gems, but each specimen - especially an exceptional stone - is valued according to its own particular quality. Prices and values have been and are continuously subject to change. Perhaps with the exception of diamonds, there is no unlimited supply of gems. True, average diamonds have lost a great part of their mystery, since they have been found in always increasing quantities, since they are traded like so many other commodities and since their supply and prices are well regulated by the large firms in South-Africa and Europe. There is an unlimited stock of

diamonds in the safes of a few companies and the supply is well adapted to the existing demand. Coloured precious stones, however, rubies, sapphires, emeralds, are rare and nobody can tell when this or that mine may be exhausted. Large and fine specimens of these gems are much rarer than diamonds of equal size and - in most cases - much higher in value. The history of many a large precious stone is known, the history of others is shrouded in mystery. Countless have been the lives of men lost in search of precious stones, countless the crimes that have been committed in the pursuance of the lust for their possession. Most men and well-nigh all women share this passion for gems, and there is scarcely a story in which a special fine stone is not mentioned. Such are men! But is it entirely the intrinsic value of the precious stone that to such an extent excites the passion of men and the longing to possess it? I do not think so. I believe it is the beauty, the lustre, the colour, the rarity that are the main sources of our fascination. To possess a thing that is beautiful and rare at the same time - if possible unique - that is what we want. And then our imagination dwells on the past of our gem, when it was found, cut and sold and how it passed through the hands of so many unknown men into ours.

It was my intention to show by these few introductory remarks how the occupation with gems is by no means a dry affair, limited only to the laboratories of scientists or to traders. Almost everybody has had personal dealings with gems. But to return to the subject of this paper: it is threefold:

1. I shall give for the sake of completeness a short resumé of the main scientific facts about each gem. These have been compiled from various books (23, 25|26, 29|32) and will include a short description of the crystal forms, the physical, optical and chemical properties (Part I, Chapter I - III)

2. The second part (Chapter IV) will contain all relevant and remarkable historical and modern references to the occurrences of gems in Siam, and a description of their recovery.

3. The third part (Chapter v) will deal with the special conditions in Siam under which gems are treated, cut and traded, as well as with their sizes and value with particular reference to the development of prices in recent years. A special Chapter (vi) is added referring to synthetic corundum.

Part I

Chapter I.

Diamond

Although there is no authentic evidence for the occurrence of the diamond in this country, I propose to include a few remarks and quotations on this most precious gem which may at least be of some historical interest. Diamonds are mentioned in several ancient books about Siam, although not too much importance should be attached to those early reports.

Th. Herbert (2) who travelled in the East between 1627 and 1629 says: "The soyle is rich in diamonds. .....most uberous" (P. 317).

de la Loubère (4) who was French ambassador to Siam in 1687-8 states: "Mr. Vincent (a physician whom the envoy brought with him from Siam to France) informs me that he has seen in the hands of the Talapojns who secretly busie themselves in these researches, some samples of pieces of sapphires and diamonds that came out of the mine" (P. 14).

We read in *Turpin* (6): "In the beginning of this century one brought to the King of Siam diamonds from an occurrence, discovered near the surface, but as the occurrence gives only uncut stones and as there are no lapidaries in the country, the Siamese have taken little notice of it and the occurrence has fallen into oblivion. The private persons who had given some of these diamonds to the officials of the King, retired to Pegu annoyed that they had not received any reward." (I.P. 218-9).

Linschoten (3, I.P. 83) mentions: "At Patane some diamonds are found".

In addition a number of later writers who have stayed in Siam mention the occurrence of diamonds.

Herman A. Ring (17) quotes "Diamonds occur in Cambodia frontier regions.... ...."

In 1893 *George B. Bacon* (10) mentions "There is a small mountain, Bang Ka Chah, where it is said diamonds are procured."

Kruijt (12) who visited Siam in 1875 states: "Although Siam must be rich in precious and nonprecious metals and rocks, principally diamonds and sapphires, the mines are not worked or only in a primitive manner. These may become in the future a rich source of wealth for the country."

Gerini (18) quotes *Turpin* (6) I. P. 218) as saying "that a diamond mine had been discovered in the North of Siam about 1700, but since forgotten. *Gerini* adds: (P. 176-177) "the reason was evidently that no true diamonds were to be found there."

Finally *Nai Sanak Buraras* (28) states briefly "Diamond has not even been thought of, although there is a possibility of its occurrence", whereas the *Department of Mines and Geology* (27) strikes a more hopeful note in saying "Thailand lacks only Diamonds and Emeralds, but we have not yet given up the hope of finding diamonds some day, as they may be discovered in the rocks, rich in pyroxenes which occur in the region of Uttaradit and the emerald may be found in pegmatite dykes or schists in the metamorphic rocks."

We know of the formerly rich diamond mines in India. We further know that diamonds have been mined in Borneo, that occasional finds were made in Sumatra and China. I believe that there is still hope that one day this most precious of all precious stones may be found in this country. Some years ago about ten small white crystals were brought to me, which proved to be real diamonds. Allegedly they were collected from tin ore in the neighbourhood of

Puket. Since then the statement was repeated to me twice by other people who said that small diamonds were to be found in tin ore in the South, but I have been unable to check it.

CHAPTER II.

Corundum

The sapphire and the ruby are transparent coloured varieties of the mineral corundum. They occur in well developed crystals which belong to the hexagonal system. Characteristic of many crystals are fine parallel striations which are often bent at an angle of 120 degrees in accordance with the pattern of the hexagonal system. The hardness of corundum is 9, the next after diamond, one of the features which makes the gem so valuable. The specific weight is variable between 3.9 and 4.1. The application of heat tends to lighten the colour. Corundum by friction develops positive electricity which it retains for some time. The mineral occurs colourless and in all colours unto black. Dispersion is weak (0.018), and hence there is little fire in the cut gem. Colour is consequently the most important factor in the valuation of the stone. Dichroism is strong. When seen through a dichroscope, a good sapphire, properly cut, i.e., with the table at a right angle to the optical (crystallographic) axis, shows pure blue colour in the direction from the culet to the table, and greenish-blue colours when inspected through the girdle. A good ruby under the same conditions shows pure red when inspected through the table and yellowish-red through the girdle. The refractive index of corundum is 1.76 - 1.768. Chemically corundum is $Al_2 O_3$=Aluminium Oxide. Acids will not attack corundum, nor is it fusible before the blowpipe.

(A) Sapphire

The sapphire is slightly harder than the ruby and its specific weight is somewhat higher. The blue sapphire derives its colour

from an addition of titanium and iron to the aluminium oxide, All corundum which is not red is called sapphire. There are white, green and yellow sapphires and all variations, and combinations between those colours are possible. Often stones are multi-coloured. Such stones frequently show a zonal distribution of various colours. It is a characteristic of this variety that its colour by artificial light occasionally differs from that by natural light, being generally less brilliant by the former. Some specimens remain unchanged under artificial light, others becoming darker, even black, or changing. from blue to a reddish-purple or violet colour.

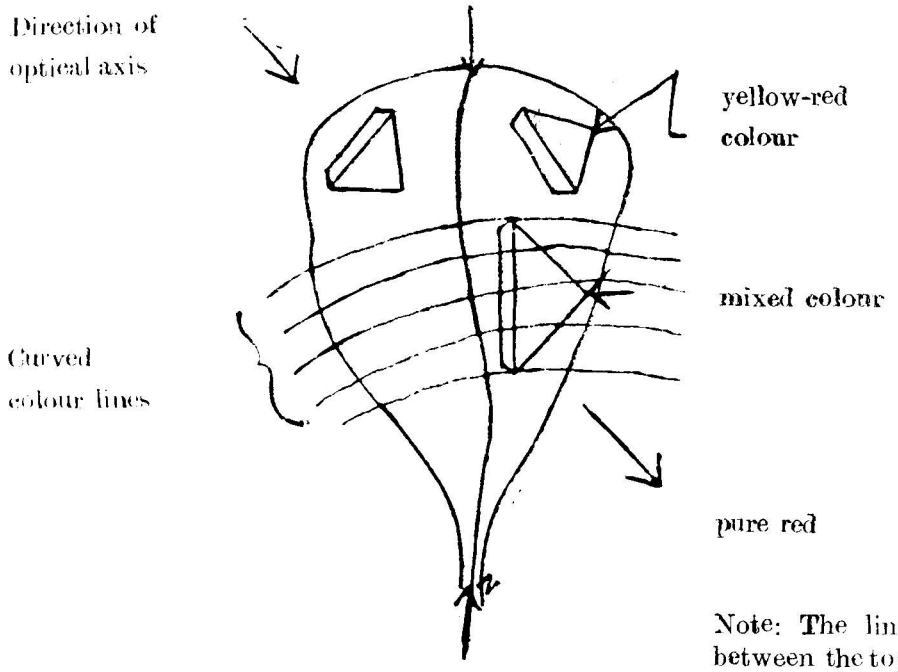
When cut "en cabochon" sapphires sometimes display a vivid white six-rayed star on the surface. This optical phenomenon, called "asterism", is due to a lattice-like interior structure of the stone. Such stones are called "star sapphires". They cannot be produced synthetically. Star sapphires and star rubies on which the star can be clearly seen in ordinary and diffused light, are rare. Most stars are clearly visible only in direct sunlight or under a strong electric bulb.

There are, however, very rare stones the inner structure of which is so suitable to produce the optical illusion, called "star," and which are so sensitive to any source of light, that double stars can be observed when the stone is exposed to two sources of light, not too distant from each other.

The effect is striking, as shown on drawing No. III, which was made from a seven-carat stone in my possession. The colour of this opaque stone is a dark reddish blue

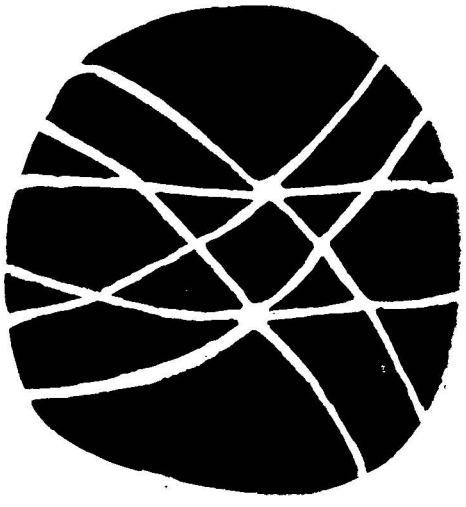
The Associated Press has recently published an article wherein it is said that perfect synthetic star sapphires and star rubies have been produced synthetically by an American Company and exhibited at the American Museum of Natural History. It is reported that the largest synthetic star ruby weighs 109.25 carats as compared with the largest natural star ruby, "the Edith Haggin De Long Star" that weighs approximately 100 carats.

Drawing 1.



Direction of colours in synthetic Ruby
(see also pages 33 and 34.)

Drawing 2.



Double Star on natural Star-Sapphire.
(enlarged 40 times)

It is said that the star is made of titanium oxide.

Before any scientific publication has been made about these synthetic star rubies and sapphires, I am not in a position to give my opinion. It has to be kept in mind that many sensational news are published by the press without proper scientific foundation. It remains to be seen whether the synthetic stones are actually identical with natural stones. I am inclined to doubt. If the star is "*made*" of titanium oxide, it would seem that the star should remain in a fixed and stationary position within the stone. In natural stones, however, the star, being merely a reflection of light produced by the lattice-like structure of the stone, glides above the surface when the stone is moved. If the star of the synthetic stone remains in a stationary position, the entire "charme" of the stone is lost.

(B) Ruby

The red colour of the ruby is due to the inclusion of traces of chromium in the aluminium oxide. The colour-tone of this gem varies greatly, ranging from a delicate pink tint to pale-rose, red, reddish-white, pure red, carmine and blood-red. The so-called "pigeon-blood" red is the choicest colour, and is the accepted qualification for the best and costliest gems. The Burmese distinguish between "pigeon-blood" red, as best colour, "chicken-blood" red as next best colour and "rabbit-blood" red as third-best colour. Within each colour-shade they distinguish again between three different tints. As in the case of the sapphire, the colour of the ruby is not always uniform within the same gem. When heated, the ruby does not lose its colour. Under artificial light the colour is greatly enhanced by the fluorescence of the stone. The common faults of rubies and sapphires are lack of clearness, presence of "clouds" or "silk", internal cracks and fissures ("feathers") and

an uneven distribution of colour. Large rubies are much rarer than large sapphires. The "star-ruby" corresponds to the "star-sapphire".

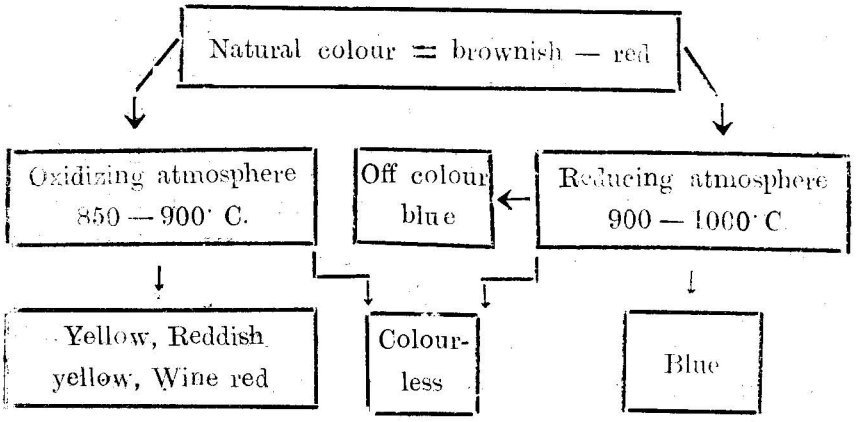
CHAPTER III.

Other gems

(A) Zircon

The Zircon is a "Mystery-stone", as it offers quite a number of so far unsolved problems It crystallizes in the tetragonal system; its hardness is 7.5 and its specific gravity is very high (4.0 to 4.8). Dispersion is very high too (0.048). The refractive index is 1.92-1.98. The colours of the zircon have a wide range from red-brown through white to dark-blue. The zircon changes its colour when heat-treated. According to *Eppler* (24) and *Kraus* (26) the heating of the gem must be carried out either in an oxidizing or a reducing atmosphere. An oxidizing atmosphere yields colourless, yellow and reddish-yellow stones, and a reducing atmosphere, blue, colourless or off-coloured stones. The heat-treatment is shown on the following:—

Table No. 1



When exposed to sun-light zircons often change to a brown or a dirty greenish-blue colour.

Zircons may also be heated after cutting and the colour or the colourless state restored by careful heating at 400 to 600° C.

Wine-red zircons are very rare and costly.

(B) Spinel

The spinel, with the chemical formula $MgO \cdot Al_2O_3$, has hardness 8, specific weight 3.50 and a refractive index of 1.72. The spinel is monochroid and can thereby be distinguished from the ruby. It occurs nearly always in connection with corundum. Red spinels are not found in Siam. There is the non-transparent black spinel which occurs in great quantities at Khanburi, often in well-developed octahedral crystals. When cut, the colour is a very deep shining black. It is cut for mourning-jewellery, and especially experienced cutters are even able to cut rings from this hard stone. At the village of Bo Ploi even the roads are covered with black spinel.

(C) Topaz

Hardness 8, specific weight 3.53, refractive index 1.61 - 1.62, has the chemical formula $Al\ (Fe)\ OH_2\ SiO_2$ It occurs only at a few places in Siam. The specimens found so far are very pale and unattractive and almost without commercial value.

(D) Garnet

Hardness 8, refractive index 1.75, specific weight 3.60 - 3.80, monochroid. Only at a few places in Siam are Garnets found and these are mostly of a rather poor colour and not comparable to those from Madagascar or Zanzibar.

Part II

THE OCCURRENCE AND MINING OF GEMS IN SIAM

CHAPTER IV.

(A) Early reports about the occurrence of precious stones in Siam are quite numerous. More than 500 years ago rubies were already dug in the Krat district as is evidenced by a quotation from *Ma Huan's* account of the Kingdom of Siam (Hsien-lo-Kwo) 1408 *Journal R.A.S. China Branch*, Vol. XXI, p. 37, 1887) (13) which runs as follows:

A hundred li (some twenty miles) to the South-West of this Kingdom there is a trading place Shang-Shwei, (Shöng-Shöü) (this may be Bang Pla-soi or Sah Söng-Sau, the ancient name of Petriu-district) which is on the road to Yün-hou-men, Wen hau-mun, (possibly Paknam-Hua-Wen, the mouth of the canal, called Klong Hua Wen between Chantaboon and Krat). In this place there are 500-600 foreign families who sell all kinds of foreign goods; many Hung-masz-ken-ti stones are sold there. This stone is an inferior kind of ruby, bright and clear like the seeds of the pomegranate. The captains of Chinese vessels resorting to Siam also use small boats to go and trade there."

Arnold Wright (20) reports that "When Captain William Keeling visited Bantam (in Java) in 1608 he met an ambassador from the King of Siam and he was told that precious stones were plentiful and cheap (in Siam)."

Anderson (14) quotes the reports of *William Eaton* (1617) and *George Ball* (1618) both of whom refer to rubies and other precious stones in Siam and Laos. "Some of these are cut by local lapidaries for use in the country and the balance forwarded to Calcutta or to Europe by the local buying agents of private and public companies."

Fernand Mendez Pinto (1) who visited Siam in 1548 says: "In the Kingdom of Siam are found rubies, sapphires in abundance."

de la Loubère (4) mentions sapphires and the *Cronica de la Apostolica Provincia de San Gregorio* (5) states (1738) that "Siam abounds in mines of rubies and sapphires."

(B) I have quoted a few ancient sources in order to show that the occurrence of precious stones was known already several hundred of years ago.

The more recent references and the descriptions that modern scientists have made of the occurrence and the mining operations will be more interesting. I propose to treat the various occurrences separately.

Pailin: The Pailin district has yielded the most and the best sapphires. Unfortunately this district, in the neighbourhood of Battambang, was ceded to France in 1907 and again in 1947. But political frontiers have not been able to stop the trade flowing in its old direction and now as before stones from Pailin are brought to Bangkok for cutting and sale.

Chantaboon: The gem-bearing gravels of the Chantaboon district are alluvial and consist of basalt (called by the Siamese "duck's liver-rocks" because it is dark and heavy) in various stages of disintegration, mixed with a clayish soil of decomposed rock. The basalt is considered to be the gem-carrier. At the beginning of the last century the mines were worked as a royal monopoly. There is a report from *Mgr Pallegoix* (9) which reads as follows:-

"Precious stones are found without doubt at several places in the Kingdom of Siam, as, when travelling, I often came across them in the beds of streams and amongst the gravels of rivers, but nowhere are there so many as in the province of Chantaboon.

"The Chinese, who plant pepper all around the large mountain of Sabab, (the "mountain of precious stones") collect them in

quantities. In the high mountains, which surround the habitations of the Xong tribe, and in the 6 hills West of the town these stones are hidden in such quantities that the planters of tobacco and of sugarcane, who have established themselves at the foot of these hills, sell them by the pound: those of the smallest size cost 16 francs per pound, those of medium size 20 francs and those of the largest size 60 francs. The principal stones, which the Governor of Chantaboon has shown me, are the following: ... topazes, hyacinths, garnets, sapphires of a deep blue and rubies of various tints.

"One day I went with a number of our Christians for a walk through the hills in the neighbourhood of Chantaboon and I found scattered over them black and greenish stones, semi-transparent (corundum), amongst which were garnets and rubies; within one hour we had collected two handfuls of them.

"As there are no lapidaries in the country, the inhabitants, who have collected some precious stones, while planting their tobacco or sugarcane do not know what todo with them and sell them at a low price to Chinese travelling traders, who forward them on to China.

"Yet, it must be noted that the King of Siam has reserved for himself certain localities where the best stones occur in greatest abundance; the Governor of Chantaboon is charged with the exploitation and sees to it that the stones reach the palace, where some second rate Malay lapidaries polish them and cut them into brilliants."

It is confirmed by *Finlayson* (7) and *Crawford* (8) that in the early part of the nineteenth century the gem mines were being worked in a small way and as a royal monopoly, but that the stones were of a poor quality. In 1857 the mines became known to Burmese and Shan traders who leased them from the government and brought their people from Burma to work them. It is said that

the rush in 1857 was brought about by the find of a certain Nai Wong who went fishing one day. But instead of prawns and fish he brought up in his net gravel which contained many rubies. He exchanged these stones against clothes which he obtained from the Gula (Shan) people. (*Department of Mines and Geology* (27)). In describing the mining at Muang Klung in the province of Chantaboon, *H. Warrington Smyth* (15) says:-

"The existence of gems (in the present Changvat Trat) has been known to the Siamese probably for some centuries, but it was not until the rigid secrecy which the government had formerly enforced (*Crawford*: (8) Embassy to Siam Vol II, P. 173) was somewhat relaxed that an immigration of (: the Shans:), these indefatigable gem miners, commenced, and fresh discoveries began to be reported every day. The Shan seems by nature designed for the pursuit of the gems. He is bitten with the roving spirit, and in addition, he has the true instinct of the miner, to whom the mineral he lives to pursue possesses a subtle charm, which constrains him never to rest or weary of its search against all odds ... The skill of the Gula (the Shan) is no less than his energy. He detects colour and recognizes quality with a rapidity and an accuracy to which few attain. No Siamese, no Lao, no Chinaman can compete with him. The Burmese is about his equal, but has not his industry or constitution, and is therefore chiefly found in the capacity of middleman, buying and exporting... The Shans are practically the only people who stand the climate of the mines for any time ... At first whole parties were decimated by the fever ... But there were other to take their place ... and although the mines still have an evil name ... the rate of mortality among the Shans is now comparatively moderate (II. p. 179-180). The Gula digger is proud and independent. He cherishes the freedom of his life, and he brooks not much official interference."

In 1895 the government made a concession of the Chantaboon and Pailin districts to a British company. This company did, however, exist only for a few years and had to give up mining after the valuable Pailin mines were ceded to France in 1907. At present the district of Chantaboon and Trat is busily prospected by Burmese and Shans. The best time for working is the rainy season. By means of the then available water, the gravel is worked and washed. The method of mining is simple and consists in digging a pit, a few feet wide and deep, and examining all the gravel within reach. During the night the water will collect in the pit. This is baled out or pumped out by means of a bamboo in the morning. Then the gravel is emptied from the pits in baskets made of bamboo and washed in the river. When the clay is freed by the motion of the basket beneath the running water, the big stones are thrown out and the remainder turned round in the basket, so that the lighter material collects at the outer edge. The remainder is thoroughly searched and all coloured stones carefully picked out.

H. Warrington Smyth (16) adds: "About noon the day's work is done, and all return to their bamboo shanties, to spend the day in gossip, in gambling, or in sorting and gloating over their stones in the sunlight, perhaps for the hundredth time. It is curious the perfect good faith observed among themselves: two or three stones may be passed round a whole crowd of onlookers without the slightest fear of loss ..."

The success of digging depends almost entirely upon chance. A stone may be found worth a fortune and then a rush will start for neighbouring places which may be sold or auctioned at high prices even before any actual digging has taken place

Trat: In former times Trat has produced large quantities of rubies, but recently the fields there seem to be exhausted. Full details are given about the various fields near Chantaboon by *H. War-*

rington Smyth (15), but quoting these details would exceed the scope of this paper.

Banggacha which is mentioned by *Crawford* (18) 1822 and later in 1893 by *Bacon* (10) is known as the place where green sapphires occur. Many pieces of corundum found there have a bluish-green colour; a few are pure green. Star-sapphires are found there, mostly very dark with blurred stars.

Zircons have been found in the Chantaboon anb Trat districts

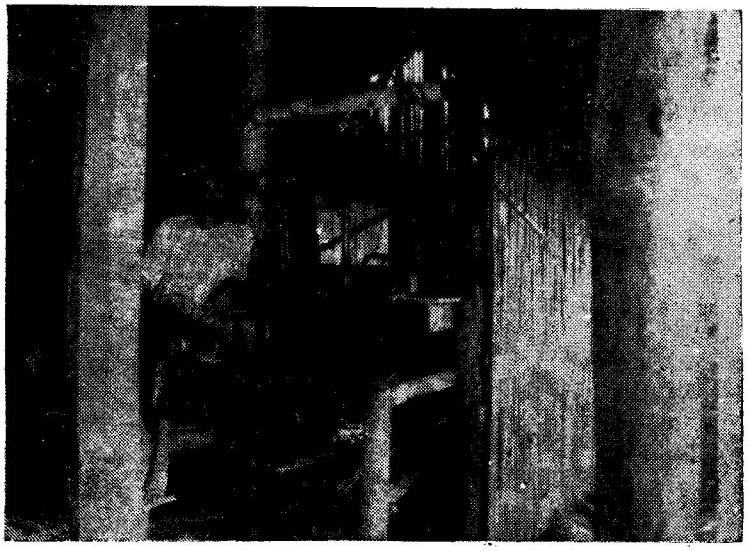
Chiengrai and Prae: The occurrences of gem in the North are recorded already by *Hallet* in 1890 (11) and various other authors. These districts arefully described by *H. Warrington Smyth* (16). The deposits at Chieng Kong on the Mekong river were discovered by Shan diggers in 1890. These diggers found black spinel-crystals ("Nin") which are invariably connected with the occurrence of corundum. After some time the diggers were rewarded in their search by the discovery of sapphire-bearing gravel in the basalt. The sapphires found were, however, of rather pale colour. Rubies are not found, although once a splendid stone allegedly having come from Chieng Kong was sent to the King of Siam. A special expedition was sent out by command of the King but it returned without results, and it was finally possible to trace the ruby back to a Burmese mine *W. A. Graham* (19) reports already in 1924 that the digging at Chieng Kong was given up many years ago, as the results proved disappointing, and today the mining-places are almost deserted.

According to the *Department of Mines and Geology* (27) precious corundum has been discovered in the basalt of Muang Long in Changwat Prae. Other places in the North mentioned by various authors are Vieng Sa, South of Muang Nan, and the district near Raheng.

Khanburi (Bo Ploi): I propose to describe this occurrence of Siam's largest sapphires at some length, firstly because I have been at Bo Ploi myself several times and secondly, because the place has been visited and scientifically explored by three good friends of mine, the late *Professor Dr. O. Weigel* (21) who was an eminent mineralogist, *Professor Dr. W. Credner*, a geologist well known in Siam by his book "Siam, das Land der Thai" (22) and *Dr. W. Fr. Eppler* (23-24) who was at Bo Ploi twice. In addition, the history of the Bo Ploi mining district appears to me as a typical illustration of the hazards in gem-mining and of all the romantic environments surrounding such a place where a great number of men seek their fortune, a few find it and so many are disappointed.

The sapphire mines of Bo Ploi are at a distance of about 30 km North of Khanburi as the crow flies, at 14° 19′ 23″ N. latitude and 99° 31′ 2″ E. longitude. It appears that the place became generally known only in 1921, although it is certain that some Burmese and Shan diggers knew of the occurrence of sapphires there already several years before that time, probably owing to the plentiful occurrence of black spinel which always accompanies corundum. As soon as the finds of sapphires had been reported to Bangkok, the district was included by a Royal Decree within the purview of the Mining-Act and licenses were issued to prospectors. It seems, however, that in the first years not much results were obtained. *Graham* (19) reports in 1923 that the results of the investigations of the Department of Mines had proved to be discouraging. During the years 1927-1928 the mine was leased by the Mines Department to a Siamese woman, Mae Sai, who paid Tcs. 46,200 for the lease. In spite of a good output during the years 1927-1928 no profit could be made. In the beginning of 1929, however, rich finds were made in the North of the field. The output in raw stones exceeded Tcs. 60,000 during the first months of the year and, according to *Eppler* (24), during the month of August 1939 alone

Digging for Sapphires among the large boulders of Theralite at Bo Ploi.
(Photo O.Weigel)



Lapidary at Bo Ploi
(Photo O. Weigel)

more than 100 sapphires were found weighing about 3300 carats and worth about Tcs. 85,000 After the death of Mae Sai and after the rich finds seemed to be exhausted, the mines ceased working in 1930 and 1931. In 1932 Mr. Riganti acquired the lease for 3 years for the insignificant amount of Tcs. 1400. Since then, however, no more rich finds have been made and at present the place is worked only occasionally by a few diggers without any good results. It is to be hoped that in future, if gem mining at Bo Ploi will be undertaken more systematically and on a larger scale the output will not only justify the expenses but even yield a good profit. All conditions for promising new finds are there and in my opinion it requires only capital and organization to make Bo Plo a paying proposition

The mining district consists of a group of low hills, formed of theralite, which are covered with large boulders. In the red weathered material which has accumulated at the foot of the hills, black spinels are found in great numbers. The sapphires are disseminated through the theralite. Here *Weigel* (21) succeeded for the first time in 1933 to find two sapphires "in situ", i. e., still fixed in the matrix of theralite. The further downwards, the finer becomes the weathered material, and the theralite that reaches down to the beds of the small creeks has disintegrated to a large degree to the so-called "sand". In the coarse material of this "sand" the chances of a rich find are especially good.

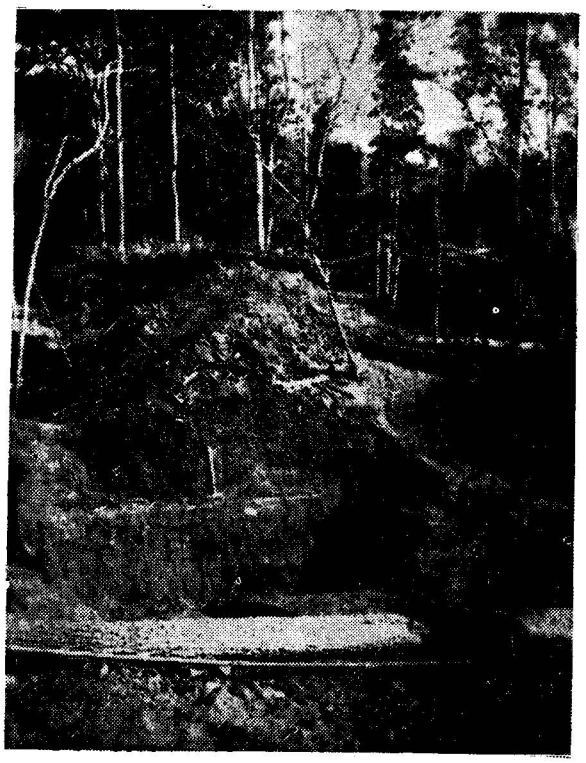
The theralite is a dark compact rock containing as prominent ingredients nepheline and plagioclase felspars. *Weigel* and *Krüger* (21) have made a number of analyses based on samples from Bo Ploi. Theralite includes a number of other minerals among which Pyroxene, Felspar, Nepheline, Olivine and Spinel are prominent. Zircons and Zeolites are frequently found in theralite.

Small plots of only a few square metres each have been given out to diggers under the sub-licenses. In 1927-30 the fee for

such a sub-license would amount to about Tcs. 20 per month, Tcs. 40 for 5 months and Tcs. 60 per year. In addition, the digger had to offer the stones for sale to the holder of the government-license first. Later - when Mr. Riganti held the government-license- no fees for sub - licenses were collected, but one - third of the value of all stones found had to be paid over to Mr. Riganti. For this purpose all stones found had to be deposited with the manager of the mine who would sell them and return two - thirds of the proceeds to the digger. As, under the conditions in Bo Ploi, it would have been easy to hide an especially valuable stone, I doubt whether this system has worked satisfactorily. There would always be the temptation and the possibility for any digger to embezzle a good stone and sell it clandestinely for his own account. *Credner* (22) gives a vivid description of the hard work of the diggers:

"With chisel and hoe they work the ground, pick it over by hand and then bring it to the surface in the bamboo-plaited baskets, which are so characteristic for the Chinese coolies. After nothing had been left for burrowing at the foot of the hills, where the ground was easy to work, mining has gone further and further uphill. The boulders of basalt, covering the slopes and the top of the hills, were worked down with the crowbars, and the fine material between them was searched for stones. In the burning sun the naked people are at work and are trying, with an iron energy, to make a fortune... Upon the whole, fortune smiles on only a few. Most of them must move away again, disappointed. It is the lot not only of the humble diggers. Also the wealthier people, who thought to make their fortune by taking out the concessions, have probably more lost than gained."

With regard to sizes and values of sapphires found at Bo Ploi I refer to Chapter v.



Sapphire pit at Bo Ploi (Photo Dr. Eppler)

Washing the "sand" for Sapphires at Bo Ploi.
(Photo Dr. Eppler)

PART III

THE TRADE IN PRECIOUS STONES IN SIAM.

CHAPTER V

Although I have been occupying myself with and have traded in precious stones for more than 20 years, it seems to me a rather difficult task to describe the numerous trading operations from the digger to the consumer. Gems are an elusive article of commerce. They are apt to avoid statistics, controls and customs officials. As all precious stones stimulate the imagination of the general public and especially of those who are dealing in this commodity, one has to use a good amount of discretion before accepting any statements or reports from the local people. To my knowledge there are no reliable statistics. Even the returns of the customs will only reveal a part of the quantities exported, because a large amount of stones is smuggled out of this country by one or another way. With inside knowledge it would be easy to write a fascinating book of all those smuggling operations. The figures about quantities and prices which I propose to state hereafter are carefully compiled and I believe them to be fairly correct. The movement of values and prices during times of war and economic upheaval is an uncertain and irregular one. In addition to the fluctuations of exchanges, the value of precious stones is likely to rise during times of war and danger. Gems represent a high value, occupy very little space, are mostly not attacked by fire, are easy to be hidden, carried or removed, and have - throughout all times - always been a favoured object for hoarding. All these facts give ample reasons for the high esteem in which they stand. These points have to be considered when following the price - development in Siam. They explain the fact that although there was only a very limited outlet for gems during the war in Siam, the demand in the local market was quite brisk and prices went up.

But before entering upon the development of prices, let us examine what qualities constitute the value of a gem. The essential properties for coloured stones are: hardness, lustre, colour and rarity. Combined with these main qualities are a number of others on which the main qualities depend. To have brilliancy and lustre, a gem must be transparent, without flaws and properly cut. The colour must be uniform and evenly distributed within the gem. All these qualities, including the rarity, cannot be influenced by men. Man can only decide the cutting, a very important factor for the ultimate quality and beauty of a gem.

Let us at first examine the corundum and see how Siamese sapphires and rubies compare with similar gems from other countries.

The most famous sapphire mines in the past were the Kashmir Mines, which are now exhausted. The gems found there are of a fine cornflower-blue with a slight reddish tint giving them a velvet-like appearance. They do not lose their colour at artificial light. Ceylon-sapphires are light-blue, Montana sapphires steelish-blue and Australian sapphiress mostly too dark, in artificial light even black.

Burma-and Siam sapphires are competing today for the highest favour of the customers of the world. It is interesting to observe how the authors of various books on gems have alternatively given the palm either to the one or the other. It is often impossible to determine the origin of a gem, because although there are certain characteristics to distinguish between one place of origin and the other-those characteristics generally disappear as soon as the gem is flawless and approaches perfection. As I have said before, there are no perfect gems-as there are no perfect men-and no two specimens are entirely identical.

The main quality of the coloured stone is its colour. Favoured colours for sapphires are: Conflower-blue, Royal-blue and velvet-blue. Sapphires should not be greenish, nor have an indigo

or an inky colour, and they should not be too light or too dark in the shade of their colours. The laws of optics teach that the more a colour approaches one of the pure ground-colours, i.e., blue, yellow, green and red, the more pleasing is the effect on the human eye and mind. Siam sapphires in Pailin and Khanburi (Bo Ploi) meet these requirements very well. *Bauer Shclossmacher* (25) considers the colour of the Siam sapphires as the standard colour, and according to my personal opinion they are the best in the world.

Pailin sapphires and Khanburi sapphires may be distinguished as follows:— Pailin: Best colours, often with reddish tints. Darker colours are predominant. The gems are inclined to lose colour in artificial light and appear rather dark. Flaws are frequent. No star sapphires are known from this location. Large gems are rare.

Khanburi: Very transparent with perfect colour; reddish tints are rare. Lighter colours are more frequent. Large specimens are frequent Rather less flaws than Pailin, except zonar striations which are very common and frequently seen in hexagonal arrangement Star sapphires of poor quality are sometimes found.

An additional factor for the valuation of a gem is its weight. The price of a gem rapidly rises corresponding to the increasing weight until the stone becomes too heavy for wearing, I have had the opportunity of inspecting and weighing many thousands of sapphires and rubies within the last 20 years and the result of my experience with regard to weight is laid down in the following table:

Table II showing the percentage of the sizes of cut Siam Sapphires of fine quality:-

All smaller than 1 carat	..... abt.	55%
1-2 „	..... „	35%
2-3 „	..... „	7.5%
3-4 „	..... „	1.5%
All larger than 4 „	..... „	1.0%
		100%

This table shows the rarity of larger stones, which finds no adequate expression in prices, as larger stones are relatively cheaper than their rarity would indicate.

The same is, by the way, the case with large pearls which are mostly undervalued. I have not collected any notes about the weight of cut rubies, nor have I handled sufficient material to give any figures. But one fact is certain: Large rubies of fine quality are many times scarcer than large sapphires. A flawless ruby of two carats in perfect colour is a rarity, a first class diamond of the same size is common.

In order to give some examples of the sizes of large stones found in Siam, I give the following figures.-

Khanburi: The largest cut stone from the Khanburi mine weighed 51 carats. It is of beautiful colour, fancy cut, of great transparency, but unfortunately shows zonar striations on the table. The stone is still in Siam.

About twenty years ago a beautiful raw sapphire was found at Bo Ploi and bought for Tcs. 12,000.- Two stones were cut out of this crystal, resulting in a flawless almost perfect gem of 28 carats and another one of 16 carats equally beautiful Both were sold in America.

The largest sapphires from Bo Ploi which I have seen are two pieces of 15 carats each. During twenty years I have inspected only about 20 stones larger than six carats and about forty stones larger than four carats.

Pailin: The largest fine stone from Pailin is said to have weighed 18 carats. It was sold for Tcs. 12,000.-

I have said before that large rubies are much rarer than large sapphires. The largest ruby found so far in Chantaboon on the "Hill of the Stars" weighs only 10.25 carats. It is a beautiful transparent stone with a light, slightly purplish colour and only a few flaws. The stone was called by the Burmese diggers the "Star

of Chantaboon". It was cut and sold in Bangkok. The next largest stone of which I know weighs 8 carats, is of a clear, dark-red colour and almost without any flaws. In total I have not seen more than about 20 Simese rubies larger than four carats.

The colour of the Siamese ruby is inferior to that of the Burmese ruby. The colour tends to be purplish or even brownish and generally it is too dark A Siamese ruby inspected under natural or artificial light will show its colour only on those facets which are directly hit by the light. Those facets in the shade will appear almost black. A Burmese ruby will appear red throughout, even on those facets which are not directly exposed to the source of light. It goes without saying that on the markets of the world a Siamese ruby is less valued than a Burmese ruby. It should, however, be stated that there are sometimes found at Chantaboon rubies which are entirely similar to those of the famous Mogok mine in Burma. Probably the Siamese ruby derives its less pleasing colour from a slight admixture of titanium which gives it a yellowish or brownish tint.

It may be interesting to compare our Siamese corundum mentioned above to some gems which are famous in the history of precious stones. I take the following data from *Bauer-Shclossmacher* (25):

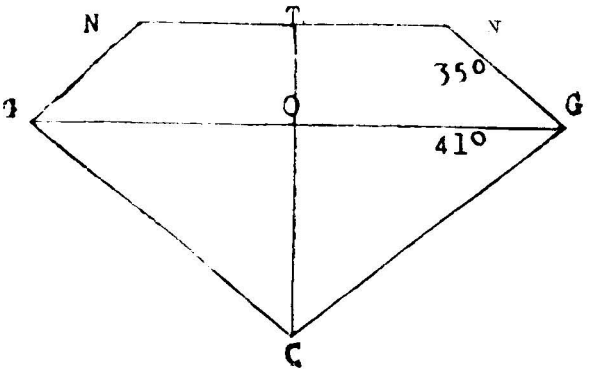
The English crown jewels contain two famous sapphires ie., the sapphire of Edward the Confessor and the Stuart-sapphire which measures 35x25mm. The treasure of the Soviet Union includes a ceylon sapphire of 260 carats. During the London exhibition in 1862 a sapphire was shown of 253 carats. The Crown of Bohemia has 18 Indian sapphires of which the largest one measures 50x40 mm. The Morgan collection contains 166 sapphires amongst them one from Ceylon, 158 carats, one from Siam, of 33 carats, a yellow sapphire from ceylon of 100 carats and the largest and the most beautiful star sapphire in the world, weighing 563 carats.

Famous rubies have been found from time to time. In 1879 a stone of 32 carats was found at Mogok which fetched £10,000.- and another one of 33 carats obtained £20,000.- In 1899 a stone of 77 carats uncut was sold for £27,000 The year 1919 brought the peace-ruby of 42 carats which was sold for £20,000.- and another ruby of 27 carats which fetched a price of £27,000.- The Morgan collection contains a ruby of 45 carats weight.

In addition to colour and weight the cut of the gem is a most important factor of its value. Although precious stones found in Siam are partly cut on primitive machines at the mining places, the majority is cut in Bangkok. Without going into details of the cuting process it should be said that great skill and training are required to cut the facets of a gem without any machinery only with the naked eye. Cutting is done by Siamese Chinese and Indians, but the most skilled workers are the Burmese and the Gulas who have inherited their ability from generations of their forefathers.

Bangkok is famous in the world for the excellence of the cut material produced here. Before the war large quantities of raw material used to be sent to Bangkok from abroad and after cutting were re-exported again. The quality of the cut influences the brilliancy considerably. The laws of optics prescribe certain proportions and angles for the ideal cut. The thickness of a stone should be about 60% of the spread, the thickness of the pavillion should be about twice the thickness of the crown. If either crown or pavillion is too thick, the gem will be "lumpy" and will lack brilliancy On the other hand, if the pavillion is too shallow, the gem will have a dead centre when seen from the table and it will have a somewhat "fish-eyed" appearance. Whereas in theory the optical laws are well known to an experienced cutter, the cutter in practice has to consider the natural qualities of the respective specimen. There is a marked tendency among cutters to cut a

Drawing 3.



Normal cut of a Diamond.

NN = Table
TC = Total thickness
GG = Spread or girdle
C = Culet
GCG = Pavillon
OC = Thickness of pavillon
GNNG = Crown
TO = Thickness of table

Remarks: With a well-cut stone TC should be about 60% of GG and TO about one third of TC.

The ideal cut of Corundum should show the following proportions:

Diameter of table: 60% of total diameter.
Height of crown: 24% of total diameter.
Height of pavillon: 41% of total diameter.
Total height: 65% of total diameter.
Inclination of main facets (upper) 50°.
Inclination of main facets (lower) 39°.

stone too thick with the obvious purpose of obtaining a high weight. Frequently no consideration is given to the law that the basal plane should be at right angles to the optical axis. The results are mixed colours.

A few words about flaws: The worst flaw in a coloured gem seems to me the uneven distribution of colours. So-called "colour-holes" can mostly be seen with the naked eye. Zonar striations, inclusions, cracks and an uneven cut are further deficiencies influencing the value of a gem. Generally it can be said that small flaws are negligible if they cannot be seen with the naked eye.

An attempt has been made to develop a scheme for the valuation of precious coloured stones. Although this scheme may be of little practical value, it nevertheless makes it possible to compare several single stones by defining their valuation figure.

Table III

The colour	(a)	has valuation figures from 1-5 The figure fixed for the best colour is 5 The respective colour figure is multiplied by 10
The weight:	(b)	(In carats) is multiplied by 4
The brilliancy	(c)	Is valued in three grades and the respective valuation figure multiplied by 3
The cut	(d),	and proportion (e) and shape (f) are valued in 3 grades and the respective figures multiplied by three for cut and two for proportion and shape.

For flaws special reductions are made:

(a) For flaws that are visible to the naked eye and in the centre of the stone: 10 points are deducted from the total valuation figure for each flaw and 5 points for each flaw at the edge of the stone.

(b) If flaws are only recognizible by a ten-times magnifying glass, 6 points for each flaw in the centre are deducted and 3 points for each flaw at the edge.

A perfect sapphire of 5 carats weight without any flaws would thus obtain the highest possible valuation figure of 100, i.e.,

(a)	Colour	: 5 x 10	: 50
(b)	Weight	: 5 x 4	: 20
(c)	Brilliancy	: 3 x 3	: 9
(d)	Cut	: 3 x 3	: 9
(e)	Proportion	: 3 x 2	: 6
(f)	Shape	: 3 x 2	: 6
No deductions for flaws :		- -	100

As I said, this scheme is an attempt to express the value of a gem in one figure. Its practical use is limited, as there is no ultimate arbitrator for the valuation of, for instance, the different shades of colour. The scheme nevertheless gives certain indications for the difference in value of each particular quality of a certain gem and thus makes it possible (cum grano salis) to classify and to compare several specimens according to their respective valuation figures. After all it seems nearly as difficult to concentrate all the various good and bad qualities of a certain gem into one figure, as those of a man.

The recovery of gems has been described in Part I. Let us now follow the gem from its birth-place to the lady who wears it in her engagement ring.

The raw stones are collected in lots or parcels and generally sold as such on the spot or in Bangkok. To buy a parcel of raw stones is an art which I have never attempted to acquire. It seems to me too dangerous and more or less a gamble what it actually is. Only well experienced gem-miners and traders are able to do it and

make a profit. Even the purchase of a single raw stone is a gamble. Nobody knows for certain how the gem will turn out. Interior tensions may cause a crack during cutting and spoil the gem. New flaws may appear during the process. They have to be taken away again, the stone has to be cut and recut, and finally a tiny gem is obtained instead of what promised to be a ten-carat stone. Generally 30 - 35 % of the weight of the raw stone is obtained as weight for the cut gem, 40 % is very good, 50 % is exceptional. The risk in connection with the selection of the raw stones explains the large difference in prices between raw and cut stones. After a cutter has acquired a parcel of raw stones, the stones are cut in the usual way. I shall refrain from describing this intricate process which is more or less the same all over the world. It is a fact that there are a great number of famous and first-class cutters in Bangkok, especially Burmese and Gulus as well as Siamese and Chinese. Unfortunately the tendency of obtaining heavy gems induce many cutters to neglect the optical laws and thereby they often spoil the colour. Each and every sapphire and ruby has only one direction in which it should be cut in order to show the best colour. Any deviation from that direction causes a deterioration of colour. A common fault with gems cut in Bangkok is that they are cut too heavy (again to increase the weight and to obtain a higher price.) Buyers should refuse to buy such stones and thereby force the cutters to give the stones the proper proportions. Naturally the shape of the cut stone is adapted to the shape of the raw stone, but the shape must remain within certain limits, i.e. within the possibility of using the gem in jewelry. The so-called table cut involves greater loss in weight and gems cut thus are higher in price. The same is the case with diamond-cut gems. The most usual cut is therefore the fancy-cut, a rectangular or square-shape cut without corners, also called octagonal or emerald cut.

After cutting the gems are divided in lots or parcels according to their colour and size. The composition of parcels, attractive

for sale, is another art (and secret) of the gem-dealer, not easily described. No parcel will contain uniform good stones. Nearly all parcels are mixed. Let us assume a parcel of sapphires may contain 20 pieces of a total weight of 42 carats. The average weight per gem is over 2 carats. Such a parcel will frequently contain several stones of 3 carats each and more, all of them probably of inferior quality. It will further contain a few good two-carat stones which will "catch the eye". In addition, there are several small stones, say, down to 1 carat each. The price asked for is for 2-carat stones, and now it is up to the buyer to "pick out" or to bargain on the complete parcel in true oriental fashion. In almost every case the initial demand is about 30 - 40 % higher than the closing price. It is a battle of wits and the seller is mostly the winner especially when there is a good demand and a rising market. Naturally the seller resents the buyer selecting only the good gems from a parcel. The seller may be justified in asking double the price if selection is permitted. The bargaining will last for some time until finally a compromise is reached. Let us assume that the cutter has sold his parcel to the exporter. The latter will generally buy several parcels, mix them and assort them again, suitable for the buyer abroad. A margin of profit of 25 % is considered as reasonable for the exporter, but generally the margin will be much larger. After the parcels have been exported - the export duty at present is 5 % on the value and the authorities have the right to appraise the gems themselves - the whole-sale dealer abroad will assort the gems again and sell them in small parcels to retail-dealers who in their turn sell them to jewellers. It is easy to imagine how the price will rise during the course of these transactions. Considering the fact that there are frequently some brokers or commission-agents inserted between the main stages and that in addition to duties all sorts of taxes have to be paid in the various countries, it goes without saying that the lady, say at Tiffany's in New York,

will have to pay a high price for her ring. In justice to the trade it must be said that every dealer runs not only the risk of changing fashion, market fluctuations, etc., but in addition is bound to be left with some gems which are not saleable or have to be disposed of at a loss. The wholesale trade in precious stones is a difficult one. It lies in the hands of an astonishingly small number of large firms in each country. It requires considerable capital and a vast amount of experience.

The main places of wholesale trade are New York, London, Switzerland and India. In former years Idar in Germany was a famous centre for cutting and trading. The most important market for zircons is America. Large quantities were exported to the United States after the first and the second World Wars. The indiscriminate supply of zircons to U. S. A. by a large number of firms and private persons in Bangkok caused a marked drop in prices, and at present the markets all over the world are quiet. After world trade has assumed more normal conditions and the extraordinary fluctuations in exchanges have ceased, a regular business in precious stones may confidently be expected between Siam and the other countries of the world.

The following tables will give an approximate indication of the development of prices in Bangkok The margin within each category is naturally as great as the differences in quality within the respective category.

Table IV

Wholesale prices of cut Siam Sapphires and Rubies of medium to fine quality paid in Bangkok in Ticals per carat weight.

Siamese Sapphires

Size	*1938*	*1943/4*	*1947*
Smaller than 1 carat	5 — 20	10 — 40	60 — 200
1 — 1 $\frac{1}{2}$ „	25 — 50	50 — 120	250 — 700
2 — 3 „	55 — 200	150 — 300	800 — 2000
Larger than 3 carats	250 — 500	400 — 1000	1500 — 3500

Siamese Rubies

Size	*1938*	*1943/4*	*1947*
Smaller than 1 carat	3 — 15	8 — 35	50 — 120
1 — 1 $\frac{1}{2}$ „	20 — 40	40 — 100	200 — 600
2 — 3 „	50 — 150	80 — 250	700 — 1500
Larger than 3 carats	200 — 500	400 — 800	1500 — 3500

It should be considered that the official rate of exchange in 1938 was about 11 Ticals to the Pound, whereas now it is officially 40 Ticals and in the open market approximately 75 Ticals to the Pound. Further: Specially fine pieces of any species and size may easily command at least the maximum price quoted.

Table V

Wholesale prices of cut zircons of fine quality paid in Bangkok in Ticals p' carat weight:

A. Blue:	*1925*	*1938*	*1947*
1 carat	.50 — 1.50	1 — 3	10 — 20
2 „	2.00 — 2.50	4 — 5	20 — 30
3 „	3.00 — 4.00	6 — 8	30 — 40
4 — 5 „	5.00 — 8.00	10 — 15	50 — 70
B. White	*1925*	*1938*	*1947*
1 carat	.50 — 2.00	1 — 4	5 — 7
2 „	2.00 — 4.00	4 — 8	10 — 15
3 „	4.00 — 6.00	8 — 12	20 — 30
4 — 5 „	7.00 — 12.00	15 — 25	40 — 60

The so-called "small carat" for zircons was introduced into the trade in 1945/6 by some dealers. Similar to the valuation of pearls, the weight of a stone is multiplied by its own weight again and then multiplied by the carat price. This is the old rule of Tavernier. For instance, if a parcel of zircons contains 24 stones of 60 carats total weight the price for the parcel is valuated as follows:

60 : 24 = Average weight 2.5 carats p piece. The average is multiplied by the "small carat" price, say, Tcs. 12.-, i.e , Tcs, 30.- and then the total weight multiplied again by 30, resulting in Tcs. 1,800.- for the parcel. Similar for single stones: 1 zircon = 3.5 carats at Tcs. 12.- p' small carat costs: $3.5 \times 12 \times 3.5$ = Tcs. 147.-

The "small carat" appears to me as a "trick" of the local trade introduced in order to raise the price level. The law of supply and demand will limit its life-time or reduce its value to a proper level. Its advantage lies in the fact that only one price each for blue and white zircons should be quoted in "small carats" irrespective of the sizes of the stones, but here again the practice shows that according to the changing demand for various sizes different prices are quoted per "small carat".

As an example for sapphire prices as quoted abroad I quote on the following *Table VI* prices as they are given by (1) *Smith* (29) and (2) by *Messrs. Talbott & Dann* in the "Chicago Tribune". The prices are to be understood per carat in English Pounds.

	Smith, 1940 *London*	*Talbott & Dann* *Chicago* 31.8.1941
Sapphires, fine quality		
1 carat	20	30
2 carats	25	50
3 „	35	70
4 „	45	100
5 „	--	250
	Smith, 1940 *London*	*Talbott & Dann* *Chicago* 31.8.1941
Sapphires, medium quality		
1 carat	10	15
2 carats	12	25
3 „	16	35
4 „	20	50
5 „	--	125

Finally a few words about the value of Star Sapphires and Star Rubies: Generally the value of such stones is not great, unless they have good colour and a clear and well-centred star. Most stones with good colour have a poor and blurred star, and most stones with a distinct star are of poor colour. Only if colour and star combined are good and the gem is of appreciable size the value will exceed that of a cut stone. Star sapphires found in Siam are mostly of poor quality. Quite a number of dark, almost black or dark-green stars are found at Bangkaja and Khanburi. Nearly all star rubies sold in Bangkok come from Burma. Good star sapphires mostly are from Ceylon. Almost perfect star sapphires or star rubies will fetch a very high price in America where the stones are very fashionable and the ever increasing demand surpasses the present possibilities of supply.

The total production of Sapphires and Rubies during a normal year before World War I in value was about £75,000 for rubies and £375,000 for sapphires.

CHAPTER VI

Synthetic Corundum.

It is evident from the foregoing that sapphire and ruby are the most important gems of this country. As both of them are manufactured synthetically it might be opportune to deal with the process of manufacturing synthetic corundum in a more extensive way and, in particular, to investigate the question as to what extent synthetic corundum has been able, or is likely to supplant the natural gem Verneuil invented the process in the nineties of the last century, but the method was not published until 1900. Purely and very finely divided alumina is placed into receptacles and small quantities are allowed to drop at regular intervals into a flame produced by a mixture of oxygen and hydrogen. During this process the colouring matter is added: 2% of iron oxide and 1% of titanium oxide for sapphires up to 3–7% chromium oxide for rubies.

By the flame, at a temperature of about 1900° C, the alumina is melted and the liquid material settles on a pin of fire-proof material. Thereby a boule is formed which is slowly rotated during the process. As soon as the boule is allowed to cool down, it crystallizes. The result is corundum of essentially the same physical and chemical properties as natural corundum. The same process performed by nature during a long time is repeated by men in a few hours. There are factories in Europe which manufacture thousands of carats of synthetic corundum every day. But is the product of these factories exactly the same as the natural gem? The reply is in the negative. There are some distinct features in which the natural gem differs from the synthetic material. The latter shows slightly curved structure lines produced by the rotation of the boule. Gas bubbles are frequently present if the alumina powder is fed irregularly into the flame. It is difficult to add the colouring matters evenly, so that frequently an uneven distribution of colour is apparent. With further progress of technical arrangements these differences may, however, in the course of time, be removed. The most important difference is the lack of definite orientation in the cut synthetic stones. As I have said before, rubies and sapphires should be cut with the table parellel to the basal pinacoid or (in other words) at a right angle to the optical axis. This produces the best colour, pure red and pure blue. It is always possible to cut a natural corundum in this way, although it is not always done by the cutter who wants to save weight and to produce a big gem. The optical axis of a synthetic corundum crystal is, however, not identical with the central axis of the boule, but is at an angle to the latter (see drawing No. 1).

Furthermore: Nature's cooling process is slow, men's is quick. The quick cooling of the boule creates internal tensions with the result that each boule cracks when removed from the holding-pin. It is therefore impossible to cut a synthetic stone of any considera-

ble size from the broken boule in the right way, i.e., with the table at a right angle to the optical axis. The result is that owing to the dichroism of corundum, the colours of most synthetic gems are mixed and are not pure; they are however satisfactory enough for most practical purposes. It follows that a cut gem of large size which shows no dichroism observed through the table by means of a dichroscope is always a natural one. In other words the pure colour of larger stones cannot be produced by the synthetic process. For practical purposes it might suffice to observe a particular stone through a ten-times magnifying glass, which, if the stone is synthetic, will show to the trained eye slightly bent structure lines or the presence of gas bubbles. To the expert the colour is a good, if not an always reliable indication. It goes without saying that any buyer of a ruby or a sapphire should - when in doubt - seek an expert's advice. Although the stock of synthetic material was low during the war, new material has arrived from abroad recently and the danger of being cheated by unscrupulous dealers becomes greater every day. It must be stated however that most dealers in Bangkok on enquiry will state whether a stone is natural or not. But some people may not ask and may be misled by the fact that so many synthetic rubies and sapphires in Bangkok are set in beautiful rings and surrounded with genuine diamonds.

It was quite natural that the invention of Verneuil caused a shock to the ruby and sapphire market. The prices for natural stones at first went down and recovered only after science had discovered ways and means of distinguishing between the natural and the synthetic corundum. Since then prices have reached their old level and have advanced, especially so during the war and mainly owing to the fact that fine stones are getting scarcer every year.

It is interesting to investigate the psychological side of this fact, because it sheds a light on human nature. One should think that only a rather fastidious connoisseur would insist on his sapphire

having grown in Siam instead of having been manufactured at a factory in Switzerland and that for this fastidiousness he should be prepared to pay a large amount instead of a negligible sum. But such is human nature: If a man can afford it he wants the "real and genuine stuff",not a piece of synthetic corundum manufactured in the nick of time, be this gem ever so similar to the natural gem. I am even inclined to say that the invention of the synthetic corundum has increased the value of the natural genuine gem. This may even be due to the very fact that synthetic stones are manufactured in such large quantities and are therefore so cheap. But the main reason seems to me the indefinable charm of natural rubies and sapphires that lies in the secret of their formation deep in the lap of mother earth and all their particular properties which their synthetic step-brothers are lacking.

There is no danger that the genuine sapphire and ruby will ever be supplanted by synthetic stones, as little as the cultured pearl has been able to replace the natural pearl or to diminish its value.

CONCLUSION

The riches of Siam are hidden in the earth. In addition to the fertile plains where the rice is grown, the huge forests with their abundance of all kinds of timber, Siam possesses mineral resources of Tin, Wolfram, Antimony which so far have been only partly exploited. Gem-mining is still in its infancy. But there are great possibilities for the future. So far only a few mine-fields are known where precious stones are found and the digging is done in an old-fashioned and primitive way. After this war, Siam will go through a period of transition. The country will be opened up to modern machinery and foreign capital, and research and experimental work will start on a large scale. New gem-fields may be found and it can be expected with confidence that the development of gem mining and the gem-industry in this country will further

expand, that this industry will become a source of income not only for a part of the population but in addition for the Government, and will further increase the already existing fame of Siamese precious stones.

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APPENDIX

Synthetic Star Corundum

During the time this article was in print, I have been able to ascertain the facts about synthetic star corundum. It appears that the information of the Associated Press (see pages 5 & 6) is substantially correct.

I owe the following information to the kindness of Mr. B. W. Anderson, B. Sc., F.G.A., who is Director of the Laboratory of the Diamond, Pearl and Precious stone Trade Section of the London Chamber f Commerce. Mr Anderson is also the author of the well-known book "Gem Testing".

Mr. Anderson writes to me:-

1. "The new stones are undoubtedly made by the Verneuil process, as they show the usual curved bands of colour and included bubbles.

2. "The star, which is sharply-defined, is due to a network of very fine short, rutile needles, which are difficult to discern even under the microscope.

3. "The "silk" in two specimens seen, was limited in area to the crown of the cabochon, leaving the lower part of the stone clear. In the natural star stones, the silk usually extends to the base, or is concentrated there, as the lapidary determines.

4. "The silk in natural stones is heavily zoned in bands.

5. "The density of the synthetics was found to be 3.982 and 3.985, values agreeing closely with natural stones determined for comparison.

"In appearance the synthetics were bluer and more glassy than natural stones. Detection is best carried out by immersion in a liquid of fairly high refractive index and observing the distribution of colour and structure. The curved bands of colour were at right angles to the cabochon dome, indicating that the "silk" was at the side of the boule, not the crown as one might expect."

It is a fact that one more trick of Nature has been learnt to some extent by Man.

Eventually, however, I do not believe that the synthetic stars will in the long run interfere more with the trade in natural stars, than do the synthetic rubies and sapphires at the present time.

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