XINJIANG'S GEMS AND JADES

新 疆 寶 石 和 玉 石



XINJIANG PEOPLE'S PUBLISHING HOUSE

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Yang Hanchen　Yi Xianrui　Yi Shuangting　Song Jianzhong　Min Yaoming

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发展宝石工艺向国际
市场销售，争取外汇建设祖
国新疆。祝新疆各族人民为
四化作贡献。

王震 一九八二年六月三日

Inscription in the handwriting of Wang Zhen on 3rd June, 1982.

"Develop jade craftsmanship, sale to international market, increase foreign exchange and construct our motherland's Xinjiang.

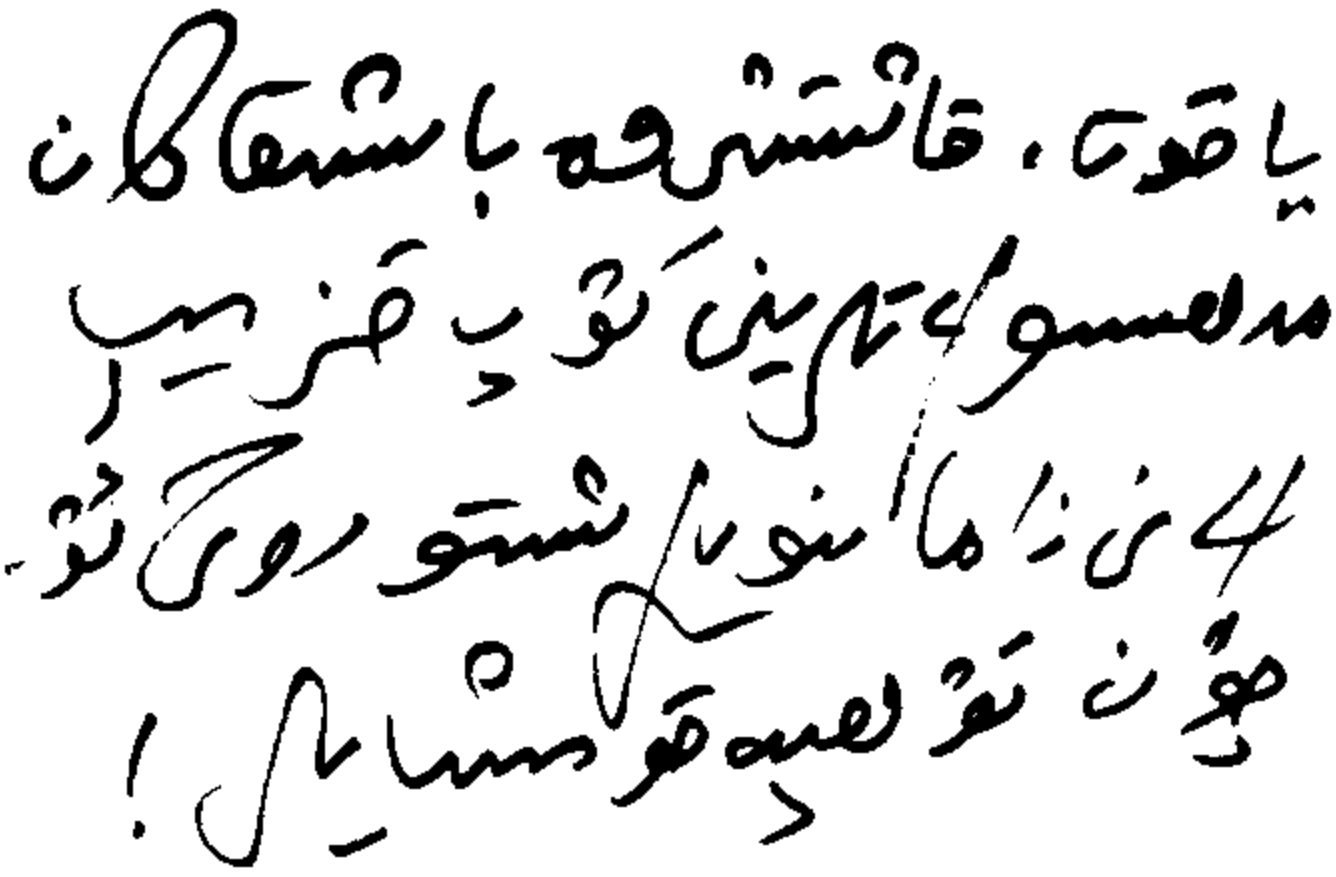
Accept my best wishes for the contribution of four modernizations by all nationalities in Xinjiang."

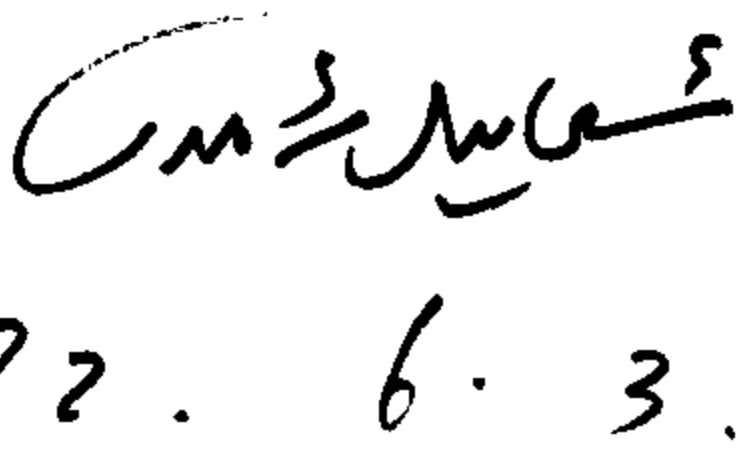
多之开采宝石、玉石，
为祖国的化建发服
务。

王恩茂

1982.6.3.

Inscription in the handwriting of Wang Enmao on 3rd June, 1982.
"Exploit gems and jades abundantly, serve to the construction of four modernizations of our motherland."





Inscription in the handwriting of Ismayil Emet on 3rd June, 1982.
"Open up gems, jades and other mineral products abundantly, make contribution for the four modernizations."

Preface

Xinjiang is vast in territory and rich in mineral resources, and it is, starting from ancient times, the "land of treasure" of our great country – China. Xinjiang's Hotan Jade has been utilised for thousands of years. The jades dug from Yin Dynasty ruins in Anyang of Henan, the pieces of jade of the "jade burial suit sewn with fine gold wire" that belonged to the Zhong Shan Jing Wang, Liu Sheng, and his wife unearthed in Manzheng county, Hebei province and the jade carving "Yu the Great-tamer of the floods" that weighed more than ten thousand "jin" and was treasured in the Palace Museum were all Hotan Jade.

Gems and jades are rare and precious technological material. Because of their bright colour and transparency, people feel a sense of beauty and they have a great admirative value. They are used as decorations and are looked upon as a symbol of wealth in many countries, and so have an important economic value. Many kinds of gems and jades are widely used in the most advanced branches of industry and medicine.

Since the founding of the People's Republic of China, with the systematic development of geological work, new gems and jades have been found. Especially in recent years, our country has expanded international contact, there is an increasing demand of gems and jades because of the development of foreign trade. It creates a new geological task – to accelerate the research, the exploration and the exploitation of gems and jades.

In order to keep abreast of the new demand, the geological work of Xinjiang's gems and jades achieved rapid development according to unified plans, and received corresponding economic benefits. After enormous work, 26 kinds of gems and 44 kinds of jades have been defined and most of them are utilised.

Xinjiang's gems and jades are one of the region's superior resources, and it is one of the provinces (regions) that makes good use of the exploitation of our country's gems and jades. In order to summarize the geological work of Xinjiang's gems and jades and the experience of their technological application, to better develop their resource superiority, to have more contribution for the development and construction of Xinjiang, the comarades of Research Centre of Experiment and Test, Xinjiang Bureau of Geology and Mineral Resources spent five years to display their fruitful results for the readers of "Xinjiang's Gems and Jades".

This book introduces systemically the kinds of gems and jades that are found in Xinjiang up till now, their characteristics, technological application and the geological features of origin. It discusses the characteristics of gems and jades as minerals and rocks geologically and the direction of research; the characteristics of being technological materials from the angle of technological application, their demands and the appraisal features from fakes, and brings about an integration of the combination of

these two aspects. As a result, it can be taken as a reference for those who work on geology and gems and jade technology.

Another characteristic of this book is that there are annotations for pictures, using pictures to explain the writing and it is rich both in pictures and writings. There are more than a hundred colourful photos, reflecting principally the general pictures of Xinjiang's gems and jades and their handicraft.

This book also applies a large number of experimental test data and carries out analysis and inquiries theoretically, and is a book that has a certain research value. Besides, the words are easy to understand, and explain the profound in simply terms, so it is also a meaningful reading of general science.

"Xinjiang's Gems and Jades" is a book that has an overall systematic introduction of gems and jades in a certain region, a great beginning for our country. I believe that with the coming out of this book, the geological work of Xinjiang's gems and jades and their utilization in handicraft will take on a new phase.

Hu Bing

May, 1985

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Introduction

Starting from the seventies, there was "a popular demand of precious stones" in the world and the price of the gemstones rose by folds. As a result, gems and jades which are used as technological materials become valuable mineral sources for people.

According to statistics, at the end of the fifties, the annual output of the global gemstones amounted to more than US $200 million, and at the end of the sixties more than US$1,000 million. In the middle of the seventies, the total output of the world's gemstones materials amounted to US $25,000 million. Many countries exported gemstone materials and gained a lot of foreign exchange. For example, the export value of Columbia's emeralds was US$2 millions in 1973 and was increased to US$40 million in 1974, and it reached US$75 million in 1979. The USSR provides more than 50 kinds of gem materials and mineral treasures in the national and foreign trade market as gemstones handicraft, for more than 25 countries and areas, at the value of 15 million roubles. United States is the largest import country of gems. In 1975, they imported gems (not including diamonds) for 820 million U.S. dollars, in 1977 1638 million U.S. dollars, and in 1979 2.4 billion U.S. dollars.

Gems and gold have the same monetary function in history. In modern times, currency devaluation happens very often, but the function of gems as a currency is still stable. The U.S.S.R. list rubies, emeralds, diamonds and sapphires as the national bank's assets, and they become the state's monetary fund of gems. In the "Diamond Bursary" of The U.S.S.R., thousands of diamonds are kept, and those which are larger than 20 Karats are named. Afghanistan put all the lapis that are mined in the national treasury. There are lots of rare treasures in private hands in the world; very often they are examined by special institutes and recognised certificates are given so as to become private fixed assets. One can foretell that, with the uplifting of people's material life, more gems, jades and their handicrafts are needed in the society, especially the demand for middle to low-grade gems will increase rapidly.

Since gems and jades have such an important economic value and Xinjiang has always enjoyed the name of "the Country of Gold and Jade", its Hotan jade and handicrafts are famous all over the world. The numerous kinds of gems and jades and their good quality have an universal appeal. As a result, the development of Xinjiang's gems and jades has a very bright future and an important economic meaning. In recent years, through enormous geological work, 10 types of 27 kinds of gems, and 16 types of 44 kinds of jades are found, most of them are used to develop for the interest of national's economy.

During the recent years, many countries reinforce the studies on gems, the characteristics of jades theemselves, their technological performance and the minerogenetic law of gems and jades deposits. Gems mineralogy, the studies on gem deposits and gem technology are gradually developed into independent branch subjects.

Gems are complete mineral crystals or mineral pieces from nature, if studied mineralogically in

great detail, it is possible to get important informations for crystal chemistry and mineralogy, so as to solve the problem of the function of rocks and minerals' formation, and thus solve some important theoretical problems of geology. Through the studies on diamonds and its associated minerals, people are able to suggest different hypothesis on the earth's crust and the nature of different layers of the earth's mantle. A.E. Fersman of The U.S.S.R. obtained fruitful results through researches on the dykes of pegmatite in Mulkinsk-Arabash region where is famous for gems. When studying the Ural emeralds, Fersman brought out the theory of "De-silicon" process of rocks. We can foretell that with further studies on gem minerals, more laws on geology will be found out.

We start from the basic theories of gem mineralogy and make use of different modern tests to study the characteristics of Xinjiang's various gems, jade minerals and rocks, including the material elements, chemical features, physical property and technological characteristics, and the use and appraisal features of gems and jades.

With the development of the science of crystal growth and the studies of the industrial application of synthetic crystals, it leads to the rapid development of artificial synthetic gems. Nowadays, many important gems like diamonds, emeralds, rubies, sapphires and opals can be made artificially.

Although artificial synthetic gems and different kinds of fakes are popular and they do bring difficult problems for appraisers, modern methods are used nowadays, (such as infrared spectrum, Raman spectrum, paramagnetic resonance and magnetic nuclear resonance, etc.) and colour elements and content, optics constant and the difference of micro hardness are used as methods of appraisal. They can distinguish more accurately natural gems from fakes. Through our concrete work, we provide our readers in this book necessary data and information in this aspect.

Gemology is still at its developmental stage. It is not complete from basis theories to the method of general investigation of mineral deposits, and needs to have further conclusion so as to reinforce scientific research and upgrade its research level. Our book has worked hard in this aspect but this is just the beginning.

At the moment, there are not many books on gems and jades, some of them put the emphasis on the knowledge of technological application's introduction and some belong to general scientific readings. "Xinjiang's Gems and Jades" tries to unify the different aspects of gem and jade minerals, the studies on rocks, mineral deposits and technology, and combine them with the specific characteristics of Xinjiang, so as to have some attempts academically and specifically. In the process of writing, attention is given to the combinaton of the following aspects: geological field observations and indoor appraisal of minerals and rocks; the macroscopic appraisal of gem and jade material and the microcosmic appraisal of different test methods; the definitions of gems and jades' varieties and the experiments of technological process.

Part of the material in the book is the first-hand information gathered by the writer, and most of the appraisals of minerals and rocks are conducted by ourselves. There is the analysis information on nephrite and Kunlun jade by scanning the transmissive electron-microscope; the data of infrared inspectrum on nephrite, tourmaline, noble triphane and amazonite, and a part on electronic probe. These materials have a fixed value on the explanation of the cause of colour of gems and jades. In order to define the new variety of gems and jades, trial polishing and carving are conducted on each one of the newly collected mineral and rock, and trial sale is conducted for some of them. If the results are satisfactory and the mineral has a fixed production, the new variety is thus defined.

This book is written by Yang Hanchen, Yi Xianrui, Yi Xuangting, Soung Jianzhong and Min Yaoming from the Research Centre of Experiment and Test, Xinjiang Bureau of Geology and Mineral

Resources. The colour photos were taken by Gao Lauging, Fan Jao Jian, Wu Chunzhang and Feng Fei. The black and white micrographs are taken by Zhu Cheng Ying and the infrared spectrum is analysed by Yu Guimei.

In the process of information-collecting, a lot of help came from Bureau of Geology and Mineral Resources of Xinjiang, the concerning basic units and other departments, and they provide a lot of valuable first-hand information for this book. In the course of writing, concrete guidance was given by senior engineers Hu Bing, and Zhang Liang Chen and help part of the information. Besides, valuable opinions were given by engineers: Yan Hongbing, Li Benghai, Zhang Yongge and Xue Xudi in the course of studies results appraisals. And the associate Professor Wang Gongque of Xinjiang's Technological Institute granted the favour of reading the manuscript, and put forward very constructive amendments. All of them own our heart-felt thanks.

The book "Xinjiang's Gems and Jades" can be described as the fruit of labour and wisdom for the geological workers of different nationalities in Xinjiang during thirty years of time. Without their endurance of the hardships of an arduous journey of fieldwork, this book cannot come out. Here, we are just trying to absorb the valuable experience from former workers and the present world of gems and jades, and do some work of sorting out the summarization according to our practice. However, because of the limited level of the writers, and the inexperience of conducting, for the first time, a comprehensive sorting out of the information of the gems and jades in a certain region, criticisms pointing the inappropriateness and errors of the book are earnestly requested.

Chapter One A Brief History of the Exploitation and Utilization of Xinjiang's Gems and Jades

Xinjiang is situated in the north-western frontier of China. It is vast in area and rich in resources. Various types of gems and jades are produced abundantly, among which Hotan Jade is famous far and wide, and it has a long history of exploitation and utilization. Here we emphasize on the brief history on the exploitation and utilization of Xinjiang's nephrite, gem, crystal and agate.

I. A Brief History of the Exploitation and Utilization of Xinjiang's Nephrite (Hotan Jade and Jasper Jade)

The New Stone Age

The exploitation and utilization history of Xinjiang's nephrite started before the New Stone Age. Among the unearthed artifacts from the site of historic relics of the Age in China, ornaments made of jade were found. For example, jade articles from the early period of the New Stone Age, such as jade pieces, jade villous themeda and jade bades were found in the layer of Hemudu Culture (5000-4750 B.C.) which was situated to the northwest of Hemudu Village, Yuyao County, Zhejiang Province,in 1976; during 1956-1973, dozens of various jade articles were found from the layer of Majiabin Culture (about 4750-3700 B.C.) to the layer of Liangzhu Cuture (about 3300-2250 B.C.) in the Caoxic Mountain in Wu County, Jiangsu Province, of which from the layer of Liangzhu Culture were delicately made, and the Cong (a hub-shaped jade with octagon on the edge and a hole in the middle), and the Bi (a round flat jade with a hole in the middle) were identified to be of nephrite. In 1976 in Shenshan County, Shanxi Province, sickles and axes made of black jade and grey jasper were unearthed in the historical site of the Longshan Culture of Shimao. In Xinjiang, a jade axe was once found on the Luobunaoer (the Luobubo Lake) early historical site. "It was carved in nephrite jade, fine and smooth, with its size similar to the axe nowadays. Tried with the thumb, it was as sharp as a knife, and put it to the sun, it was shining." The above facts show that jade was used in our country since the New Stone Age, and most of the materials came from Xinjiang. It means that in the New Stone Age, Xinjiang started using nephrite in making tools and ornaments.

We also know, from the recorded history of our country for about four thousand years, that there were writings about Xinjiang's jades in the remote legendary period of Yellow Emperor four thousand years ago. For example, in the earliest geographical writing of our country, A Book of Mountains And Seas recorded in the Mishan Mountain there production were almost in white Jade and white jade cream and Yellow Emperor took some jade from the Mishan Mountain and buried it on the southern side of the Zhongshan Mountain. A Suppliment to a History of the Yue State, by Yuan Kang of the Han Dynasty mentioned, "At the time of Yellow Emperor jade was used as weapons to cut the trees for constructing recorded buildings." The Chronicles in Bomboo Strips, "In the ninth year of the reign of Emperor Shun of the Yiouyu family, Queen Wangmu of the West came to the Court to pay nomage by presenting present the "white jade rings" and jade pieces. It shows that the history of Xinjiang's jade utilization was long-standing.

The Shang Dynasty

In the Shang Dynasty, jade was widely used in making sacrificial vessels and ornaments. "The jade-product technology in the Shang Dynasty was of a high standard. The aristocrats, men and women, wore jade articles as ornaments. Jade was also used in carving various sacrificial vessels, such as 'Gui' (an elongated pointed tablet of jade held in hands by ancient rulers on ceremonial occasions), 'Zhang' (a jade tablet), 'Bi' (a round flat piece of jade with a hole in its centre, used for ceremonial purposes in ancient China), and 'Cong' (a long hollow piece of jade with octagon shape) so as to show their noble identity. There were also jade articles for admirative purposes which were carved in exquisite craftsmanship. On some bronze ware, jades were also set in part of it and became precious compound objects". (A Draft History of China, by Guo Moreo). At the Yin Dynasty Ruins in Anyang County, Henan Province, hundreds of jade articles were unearthed from the Fuhao's Tomb. The materials used were white jade, grey jasper, black jade and green jade. These jade articles were presented to the Emperor of Shang as tributes. From the jade articles in the Ruins, it is estimated that Hotan Jade had been exported in large quantity to the Central Plain Provinces of China before the late Shang Dynasty, and that was more than three thousand years ago.

For the quality and sources of the jades dug archaelogically, there was not yet any unified conclusion. There were three different views: one was that they included nephrite and jadeite. Zhang Hongzhao thought, "The jades of ancient times that were worthy of the five virtues enumerated in A Book of Characters (Shu Wen Jie Zi, by Xu Shen) were nephrite and jadeite (jade). Another view was that there was just nephrite and it originated from Xinjiang. As pointed out by Sung Yingxing of Ming Dynasty, "For the jades that came to the central part of China, the precious ones all from Yutian. According Joseph Leight of England, he said,"There were a lot of discussions about the origins of jade. After some detailed discussions, it was agreed that Xinjiang's Hotan jade, mountains and rivers around Yerqiang were the main, or perhaps the only jade – producing centres for more than two thousand years. Another view was that they included nephrite, serpentines and Nanyang jade which were similar to nephrite. As said by Xia Xiangrong, "Something should be pointed out and that was, although there were various names for ancient jades, from the unearthed jades and jade articles handed down, most of them were made of nephrite or jade materials that were similar to nephrite. As to whether jadeite was included,it is a problem to be discussed." The analysis on the unearthed jade articles shows that the jade

had a good quality, a high hardness and a good tenacity and it shows that it was nephrite. Basing on the unearthed jade articles dug from the Fuhao's Tomb in Anyang's Ruins of the capital of the Yin Dynasty, the Geological Institute of the Academy of Science of China conducted a chemical analysis and believed that they were in nephrite, mainly constituted by tremolite in silicate. Here is the chart on the chemical result analysis of the ancient jade from the Fuhao's Tomb in the Ruins of the Capital of the Yin Dynasty contrasting with Xinjiang's modern nephrite.

It was found that the SiO_2. MgO and CaO content of ancient jade was basically the same as that of Xinjiang's nephrite presently exploited. Because of that we think that most of the ancient jades originated from Xinjiang.

The contrast of chemical aralysis result between the ancient jade of Fuhao Tomb and modern nephrite of Xinjiang.

	Ancient jade					Modern jade							Theoretical composition	
	Fuhao Tomb The Yin Dynasty Ruins[+]					Hotan		Yutian		Qieme		Tianshan	Tremolite	Actinolite
	remain jade pieces	jade lance pieces	jade	nephrite knife	jade ring belt	sheep fat jade	white jade	grey jade	white jade	grey jade	white jade	jasper		
Colour	light yellow	brown	light green	white		white	white	grey	white		white			
SiO_2	52.92	57.34	57.77	57.14	59.00	56.08	56.15	56.23	57.40	58.86	55.00	54.00	59.2	56.9
TiO_2						0.000	0.08	0.000	0.000	0.11	0.03	0.01		
Al_2O_3	2.90	0.52	1.06	1.00	0.72	0.79	1.02	1.10	1.10	2.27	1.27	1.82		
Fe_2O_3	0.66	2.15	0.45	0.83	0.07	0.50	0.62	0.18	0.13	0.61	0.3	1.43		
FeO	0.22	0.41	0.50	0.47	0.32	0.78	0.78	1.38	0.54	1.5	0.82	4.10		8.3
MgO	25.32	24.4	24.71	24.71	25.31	24.82	24.08	24.02	24.42	21.34	21.3	22.13	24.8	19.1
CaO	11.88	12.70	12.73	12.73	12.61	13.23	13.20	12.50	12.77	13.10	17.41	11.39	18.3	13.3
MnO						0.07	0.18	0.12	0.08		0.03	0.11		
NiO												0.22		
CoO												0.01		
Na_2O	3.00	0.38	0.70	0.48	0.48	0.21	0.21	0.24	0.16	0.36	0.24	0.21		
K_2O	0.18					0.10	0.10	0.24	0.27	0.3	0.02	0.06		
P_2O_5						0.03	0.08	0.03				0.02		
Cr_2O_3												0.35		
SO_3						0.16	0.11	0.25	0.09			0.05		
CO_2						0.56	1.20	0.24	0.20					
H_2O^+	1.73	1.50	2.08	1.47	0.84							4.20	$H_2O = 2.2$	$H_2O = 2.1$
H_2O^-	0.13		0.61		0.56									
Ing.loss						3.07	3.22	3.32						
Total	100.09	99.776	100.52	99.646	99.956	100.40	101.03	99.85	96.94	96.49	96.42	100.4	100.0	100.0

Zhang Peishan, 'Appraisal of Gems and Jades from the Fuhao Tomb of the Ruins of Yin Dynasty'. Archacology No. 2, P.204, 1982.

The Western Zhou Dynasty

The Zhou Dynasty followed the Shang Dynasty and the varieties of jade handicraft were numerous. Because of the establishment of the patriarchal system, and the academic and ideological development, jade articles were moralised philosophically, religiously and politically. A special office was instituted for the management of jade articles. The ceremonial vessels were made of jade, consisting, mainly, of six tokens and six instruments. A system for sacrificial vessels was set up, there were special officials responsible for the appraisal taking care and utilisation of jade articles and their products. Sets of jade articles like precious stones worn at the waist "Yu Pei", well carved precious stones and rings were produced as gifts among the nobles. The designs of the jade articles and their varieties of this periods possessed the elegant style of the Zhou Dynasty's ancient jades. During the period of Western Zhou, it was believed that around the area of Kunlun, there was a tribe especially engaged in mining precious stone. Chronicals in Bamboo Strips recorded that the ruler of Zhou (B.C. 998), arrived at Kunlun, he praised and agreed, "Kunlun is the best mountain all over the world, that you can find all the precious & valuable mineral." It was also recorded in The Biography of Emperor Mu of the Zhou Dynasty, "People in the times of Western Zhou, around the area of Kunlun, specialised in gathering jades, and they went to the river to dredge jade. When it was summer or Autumn, the local people went to the rivers and dredged jade in groups. They lined up hand in hand, and walked along the river. If their feet touched any jade, they would bend down and pick it up. It explained the method of gathering jade during the period of Western Zhou. The Biography of Emperor Mu also recorded down, "The Emperior had the jades opened up, loaded in three carts and packed with ten thousand lumps of the jades home." When Emperor Wu of Zhou Dynasty overthrew Shang Dynasty, he captured Shang's ministers with fourteen thousand pieces of jade articles and approximate eighty thousand pieces of jade pendants. This gave a picture that jade articles were valued highly and wore inseparably for the ceremonial usage before the court in the West Zhou Dynasty.

The Spring and Autumn Period

During the Eastern Chou – the Spring and Autumn Period, Reflections of the King of Huainan, by Liu An of the Han Dynasty, "The jade of Zhong Shan (Kunlun Mountains) if burned with coal for three days and three nights, the colour will not change." The Royal Family of the Kingdom of Zhao: Sketches of History, by Sima Qian recorded, "Su Li, in a letter to King Huiwen of the Kingdom of Zhao, mentioned that if the soliders of Qin State were dispatched to pass over the Guozhu Mountains and cut off the route via the Hengshan Mountains, the thoroughbred horses and dogs of the western region would not be exported to the eastern states and the jades from the Kunlun Mountains would not be exported either. Sire will not take these three precious possessions." In the chapters titled Light and Heavy in the Book of Guanzi, the words "the jade of Yushi (Yueshi, it also reads Rouzhi) were mentioned for several times. Yushi means Yueshi (it also reads Rouzhi), the country that came to prosperity during the Spring and Autumn Periods, including the area from Ningxia to the vast region of Xinjiang. During the Period of Warring States, Xinjiang's "Bi" (a round flat piece of jade with a hole in its centre) was easy to carry and had a very high value. If used as a currency, like, "Pearls and jade as the superior currency, gold as the medium one, knives and cloth as the lowest", the effect of "those that are few cost more, and those that are abundant cost less" can be achieved economically. The "jade of Yushi" was not only used for making sacrificial vessels, ornaments and objects of admiration for slaveowners and

nobles, but was also developed as a precious currency, and played an important part in the economic development at the beginning of the feudal society in our country. At the same time, it shows that in the Period of Warring States, Xinjiang's jade was already clearly defined as "Jade of Kunlun".

The Han Dynasty

Up to the Han Dynasty, jade-production was an important item in the handicraft industry in Xinjiang. There were jade deposits in Shanshan (Ruoqiang), Yutian – Zihe (Yecheng) and Shache and they were the place where the jade articles were produced. During the period of the Western Han Dynasty, Zhang Qian went to the Western Regions and opened the famous main route of the east and west – "The Silk Road" and Xinjiang's jade travelled along the Silk Road and was transported to the inner continent, Yumen Pass – the Jade Pass thus got the name. From the six white jade royal seals to the apparatus in offering a sacrifice to Heaven, there were more than seven thousand and three hundred jade articles, and the uses stretched tothe articles of everyday use. The components of jade burial, suit sewn with gold wire which were for the nobles in the Han Dynasty were popular among the sacrificial objects. The jade clothes were identified to be in nephrite constituted of tremolite, "after the present analysis and contrast, it shows that the jade of the jade clothes and the Hotan Jade of Xinjiang, no matter in the chemical composition or in the physical nature of the minerals, have exactly the same pattern, so it was inferred that the origin of the jade of the jade clothes may be Xinjiang's Hotan. (Zhang Peisan: A study of the Clothing of Jade and Minerals Unearthed from a Han Dynasty Tomb at Mancheng County, Hobei Province). It thus shows that in the Han Dynasty, Xinjiang's nephrite was already popular in the central plain region.

The Sui and the Tang Dynasty

During the Sui and the Tang Dynasty, people were more keen on jade articles, but there was some progress in the art of carving. In the History of the Wei Kingdom , "Thirty miles from the east of Yutian, there was a head-shaped river, in it there were jades and gems ....the mountain was in abundance of beautiful jade". In the History of the Western Frontier: "There was a jade river in Yutian, people looked at the place where there was full moonlight and they would surely get some jade." Tang Xuanzhuang, the famous monk who wrote My Travels through the Western Frontier of the Great Tang Empire pointed out, "the State of Wuziao (Yingjisha County, Xinjiang,) has mountains full of various jades, such as white jade, and grey jasper and green jade." "The Kingdom of Qusadanna (Hotan) produces white jade and grey jasper." Bai Juyi mentioned in "A word of Open-heartedness", "To try jade, one must burn it for three full days." Here, the distinction method and origins of nephrite are reflected.

The Song Dynasty

In the Song Dynasty, the art of jade – carving took a greater step than the other dynasties. In the court of Song, a special "jade institute" was established for the making of sacrificial vessels and other objects, jade seals, objects for exorcising evil spirits and charms were carved in the patterns of lions, monkeys, horses, cows, sheep, dogs and turtles. In The Biography of Emperor Taizong (939-997) of

Song Dynasty is written down. In the third year of the reign of Emperor Qiande of the Song Dynasty (965 A.D.), the Yutian Kingdom sent an ambassador to present the tribute of 500 hundred "tuan (round lump)" of jade. The jade contributed "tuan" was so called instead of the Kuai piece, and, therefore, it was inferred that the jade contributed was Hotan Jade.

The Yuan Dynasty

Emperor Kublai Khan of the Yuan Dynasty had once sent this men to Xinjiang to exploit jade, and posts were set to transport the jade to the capital. According to historical documentation: "In 1274, the governemt of the Yuan Dynasty ordered to exempt the jade-miners in Yutian from corree, saying that the jade-miners there were corree for the government." At that time, a poet of the Uygur nationality Ma Zu often mentioned in Poems Composed on the Huang River, "a Persian old merchant crossed the rivers and rode a camel at night, trying to exploit jade at the riverside in order to exchange it with cloth." The History of the Yuan Dynasty stated that the government of the Yuan Dynasty "built a government – owned mill in Datong for grinding jade. At that time, jade articles were very popular, jade articles set with silver were famous, and are elegant as decorations. "Jade ruyi", a high-class gift in the society started from the Yuan Dynasty. The "Grand Jade Tub from the Dushan Mountain" now displayed in the Jade Tub Pavilion of Beihai Park's Round Castle in Beijing was a wine decanter of Kublai Khan in the Yuan Dynasty when he was having a feast with his officials. That jade article was one of the biggest and oldest jade tableware left nowadays and was of superb craftsmanship, with the outside wall carved with dragon, hippopotamus, tortoise, seal, conch, flying fish and frogs, and they were all lifelike. The Grand Jade Tub from the Dushan Mountain was put in the Moon Hall in Yuan (1265). In the Ming Dynasty, The Moon Hall was demolished, "and the Grand Jade Tub from Dushan Mountain was found in the Zhenwu Temple near Xihuamen, Beijing, where it was being used as a vessel for pickling vegetables by the Taoists of the Temple, Emperor Qianlong (1749) had his men search for it back and establish a Jade Tub Pavilion for displaying this fantastic "Grand Jade Tub from the Dushan Mountain". This jade article was carved in black jade of Xinjiang, with its height 0.66 metre, diameter 1.5 metres.

The Ming Dynasty

The jade-carving techniques in the Ming Dynasty had more advanced development than the previous dynasties. According to A History of the Industry of the Ming Dynasty, among the tribute of Xinjiang to the inner continent, uncut jade was an important item. One scientist called Song Yingxing in the Ming Dynasty was engaged specially in discussing jade in his works the Natural Resources and Manufacturing Industries of China, pointing out the causes of formation, exploitation and the processing method of jade, "all jades ..... that are precious came from Yutian," showing that the jade-carving materials that were of good quality at that time came from nephrite of Xinjiang.

The Qing Dynasty

During the Qing Dynasty, Hotan Jade was exploited at a large scale and was transported to Beijing and other places to carve into precious jade articles. In A Survey of the Waterways of the Western

Frontier, by Xu Song of the Qing Dynasty, the colour of the jade exploited in the Maerdai and the Maerhupuke Mountains lying in the Southeast to Shache is black and the quality is hard. At that time, exploitation of Hotan Jade was at a large scale. For example, more than 10,000 "Jin" (catties) of jade was exploited during the time of the Emperor Qian Long. At that time, jade articles reached different realms of the high society. For clothing, there were the embroidary of beads, small pearls and coral small beads etc.; for banquet, there were jade cups, jade chopsticks and jade bowl etc., for living, there were the wall decorations with jade set on it, decorations for the table and chairs, bed decoration and hoops for the screens and for travelling, there were the carriage decoration, horse decoration and sedan decoration. The four treasures of the study, the writing brush, ink stick, ink slab and other artetes associated with scholarship were all decorated with jade. From the saying that a gentleman never go without jade ornament about him unless for justifiable reasons, it shows that to be keen on jade was one of the cultural features of the Qing Dynasty.In Qing Dynasty, the jade exploitation and jade carving objects of Hotan had the highest quantity in history. Shache and Hotan jade became the largest amount of tribute. The court of Qing made use of Hotan jade to carve zeals, jade books, jade brochures, and snuff bottles etc. And after 1775 large scale jade objects like the "Yu the Great, Tamer of Floods", "Longevity Mountain" "Fu Sea (Happiness)" "Nine Elder In Huichang","Going on an Excursion in Autumn" and the Spring Morning on a Red Terrace were made. The jade articles in Qing represented the essence of ancient cultural art of the Chinese nation.

Modern Times

In modern times, Xinjiang's nephrite deposits have achieved great development after special geological work. Jade carving techniques keep improving too. Xinjiang's Hotan jade provide for the jade carving factories in the whole country and many fine jade articles were carved, adding colours to our country's eastern jade-carving techniques.

The U.S.S.R. geologist H. Kolesnik in his book Siberia Nephrite described the nephrite deposits in Asia. When introducing Xinjiang's nephrite deposits, he said, "During 1882-1932, when Russian geological workers conducted surveys on geological routes in the area of the Kunlun Mountains and the Himalaya, in the river basins of the Yerqiang, the Kalangutage, the Liushitage, the Bokuzidaban, and the Asiditage River on the northern slope of the Kunlun Mountains found seven nephrite deposit sections. They described the geological features of nephrite and thought that the mineral constitutions and structure of the nephrite deposits in the Kunlun Mountains were very typical. This was the first survey and description of Xinjiang's nephrite by a foreign geological worker in modern times. The geological work on Xinjiang's jade had a faster development after the founding of new China. A general survey was conducted on Tianshan's jasper jade and Hotan jade and they achieved very fruitful results. At the same time, a scientific monographic study was conducted on jade and concluded Xinjiang's nephrite in a more systematic way.

The exploitation and utilization of Tianshan 's jasper jade was much later than Hotan jade, and its quality is far more inferior than the latter too. A survey of the Northern Mountains, a section of the Book of Mountains and Seas, says, "The southern side of the Panhoushan Mountains abounds in jade." "Jade is abundant underneath the Daxianshan Mountains." "There is plenty of copper and jade in the Huenxishan Mountains." According to Liu Tongxuen, author of the Geography of the Western Frontier, the Panhoushan, Daxianshan and Huenxishan Mountains were all in the area inhabited by the Junggar tribes of the Qing Dynasty. The Junggar word for jade was "hasi" the colour of which is green

and inferior to the jade of Hotan.

In recent years, gold and jade were found in the Arjinshan Mountains. The jade was a kind of nephrite, but the quality is inferior to jasper jade from the Tianshan Mountains.

II. A Brief History of the Exploitation and Utilization of Gems

Gems already found in Xinjiang are diamond, ruby, blue sapphire, aquamarine, aquamarine cat's eye, tourmaline , precious spodumene, purple apatite, amethyst and citrine. However, the time of their discovery and utilization differed from one another.

1. Diamond

Ancient writings had recorded the production of diamonds in Xinjiang. For example, a book entitled Lie Zi, written by Lie Yukou of the late Zhou Dynasty states, "In his Majesty's large-scale expedition on the tribes in the West, Emperor Mu of Zhou was contributed by these tribes a sword made in Kunwu and cloth woven in Dayuan. The sword, one chi and several zhi long, can cut jade as earth." History of the Five Dynasties also reports, "The land of Huigu produces diamonds." Remarks of a Shantong Native (Qi Dong Yie Yiu), written by Zhou Mi of the Song Dynasty, tells us that diamond was said "to be produced in the Western Frontier and on the mountain – tops of the Huihe Land." These historical records were not precise. Qing Dynasty, the Geography of the Western Frontier points out, "According to An Introduction to Documents in History, by Ma Duanlin of the Yuan Dynasty, the land of Huihe produces jade, diamond grains, diamond, ruby and blue sapphire." And the book, in the Section of Local Products of the area, notes, "A sort of diamond produced there, known as alemasi by the vernacular, will not melt even if burned a hundred times, and can be used to cut jade. Zhang Hongzhao, of the Qing Dynasty, marked off the area between Bole and Yining as producing diamonds, in his book entitled "A record of Ancient Minerals".

The origin of Xinjiang's diamonds described in ancient times has not yet been found. The origins known in recent years were: one was according to the information written by Bycliangfsky of the U.S.S.R.. In 1942, when he was working on the lower reaches of the Kalarashi River, he got a diamond which weighed 0.5 karat from the hands of a person panning for gold, and which was now stored in Moscow the U.S.S.R.. In the same year, at a two days' distance from the panning area of the Qirigan River, he got some diamonds again from another panning person. Another place was recently found in the South of Xinjiang. Diamonds produced in Kimberlite have extremely small size and do not yet reach gem level. But from the geological conditions of Xinjiang's origin, it is possible to find diamond deposits.

2. Ruby and Blue Sapphire

According to ancient records, around the area of the Kunlun Mountains, Xinjiang produced ruby and blue sapphire. The Chronicles of the Tang Dynasty say, "Emperor Dezong, Upon his Majesty's accession to the throne, sent an official named Zhu Ruan to Anxi to collect jade at Yutian .... who obtained there a hundred jin of jade, including white jade and blue beads, and some other treasure. Honghao, of the Song Dynasty, in his information on the Desert Land, says, "The area inhabited by the Huigus produces large quantities of blue beads." The Chronicles of the Five Dynasties says, "Turfan women wear blue beads in their hair braids. One of the best variety is worth a good horse." An Outline

of the Natural Resources says, "the state of Yutian produces blue beads, glistening with bright colour, and one bead of the best quality is worth a good horse. The bead, therefore, is known as the bead of one-horse's worth. The best variety is often of a blue or dark-green colour." Compendium of Materia Medica (Pen Tsao Kang Mu) by Li Shizhen of the Ming Dynasty tells us, "Diamond comes from the Western Frontier, often mined out of quarries and deep pits in the area inhabited by the Huigus. It falls into a number of varieties, red, green, blue and purple. The red one is called cizi, the blue dianzi, the green maja one-horse's worth, the yellow munan and the purple lazi." "Colour stone is diamond. The blue diamonds were called sese (blue beads) by people of the Tang Dynasty; the red ones were called mohe by people of the Song Dynasty. Now both varieties are known as blue sapphire." What were known as sese in ancient times are now called blue sapphire. Through a few years' geological work ruby and blue sapphire were located in the gneiss somewhere in Xinjiang, but their quality was inferior, nevertheless.

3. A Brief History of the Discovery and Utilization of Other Gems

Besides diamonds, ruby and blue sapphire, Xinjiang still has beryl, tourmaline, garnet, precious spodumene, citrine (topaz), amethyst and purple Apatite. These gems were discovered later and had a shorter utilisation period, but they have a greater economic significance.

In 1953, China and U.S.S.R.'s geological workers in the first time described the aquamarine and golden yellow beryl in the area of Altai, but they were not utilized. At the end of the fifties and at the beginning of the sixties, Xinjiang's geological department and the Xinjiang Non-ferrous Metals Corporation discovered beryl, spessartite, tourmaline and amazonite of gem level in the area of Altai, the Kunlun Mountains and the Tianshan Mountains. At the same time, in the eastern and western part of Zhunger and certain area of the east of Xinjiang, citrine, aquamarine and amethyst that were of gem level were found. At the beginning, they were just used as admirative mineral samples to be collected, but after they were defined as gems or jades, they were utilized

At the beginning of the eighties, Xinjiang's geological workers found grossularite (Altai emerald) and cinnamon stone in the mountainous areas of Altai. They were all exploited and utilized

III. A Brief History of the Discovery and Utilization of Rock Crystal and Agate.

Handicrafts using Xinjiang's agates have a long-standing history. The unearthed objects of the New Stone Age in Tuifan which were now displayed in Xinjiang's Historical Museum had agate decorations; among the artifacts of the Warring States Period unearthed in Urumqi there were cups with ears in agate. After modern geological work, many agate origins were found in Xinjiang. The colour of monochrome agates is bright, and polychrome agates constitute many beautiful patterns. It must be pointed out that the schiller agate found in Xinjiang was the first time for our country.

Rock crystals had long been used by people. Among the unearthed artifacts of the past dynasties, there were always decorations in rock crystal. There was a peeling tool in crushed quartz pieces which belonged to the New Stone Age and was also displaced in Xinjiang's Historical Museum; there were also stone kernel and stone slice made in quartz, which belonged to the New Stone Age as well and were unearthed along Lake Luobu Caoer and there was a human-shaped carved in colourless and transparent

rock crystal. It belongs to the periods of the Southern and Northern Dynasties and it was unearthed in Bachu.

The rock crystal deposits have more origins found after modern geological survey. In the sixties, a large amount of piezoelectric rock crystal, smelt quartz and industrial rock crystal were found in the southern and northern part of the Tianshan Mountains and they had an important effect on the national economy.

Lilac purple jade and wax-yellow topaz were both exploited in the eighties and now become industrial materials that go well.

Chapter Two The Classification of Gems and Jades

In order to understand the colourful world of gems and jades, people have carried on a general classification according to their domains of application, relative value, minerals, rocks and geological characteristics. Though there are numerous plans for the classification of gems and jades inside the country or from the exortic, none of them can yet be recognised as centralised and rational,whence the classification of gems and jades is a problem to be solved at home or abroad.

Many countries, for a long time, classified gems and jades in two main types: precious stones and semi-precious stones, and some are called valuable gems and semi-valuable gems. In 1916, the Japanese gemmologist, Suzukibin, divided gems into four groups in History of Gems: positive gems; rare positive gems; semi-precious gems; quasi gems. In 1927, another Japanese gemmologist Kushiyutakeo divided gems into five groups in Popular Gemmology: positive gems; semi-precious gems (famous ones); semi-precious gems (more famours ones); decorative stones (translucent to opaque, famous in history). decorative stones (translucent to opaque). In 1932, Japan's Nishiogakunyu in Talk About Gems mentioned metal ore gems and organic gems besides gems, quasi gems and decorative gems. In 1978, an Indian gemmologist, M.L. Deshpande divided gemstones in 7 types according to their chemical elements: natural elements; oxide; carbonate; silicate; sulphide; phosphate; halogenide. In 1979, an American gemmologist wrote in his gemmological work, he divided gems into five catagories: principal gems; minor gems; other gems and decorative gems; organic gems, artificial gems. In 1980, a U.S.S.R. specialist on gem mineral deposits, Keyevlinko, in the book Survey and Assessment of Gems and Jades Deposits divided gems (colour stones) into: gems; gems-jades; jades. In 1981, a Japanese gem reviewer Yikedahiroshi in Introduction of Gems divided gems into: valuable stones and semi-valuable stones. From the above situation, it is clear that there is not yet a unified classification plan.

In our country, the history of the studies of gems and jades' classification is relatively late, there are not many writings published and made known. In 1978, an engineer, Luan Bingao, in Classification and Appraisal of Gems and Colour Stones divided gems and jades in three types: gemstones; colour stones; organic stones. In 1979, Liang Yongming in Gems and Jades also divided gemstones in three groups: gems; jades; stone carving materials and stones for building and decorations. Assistant researcher Wang Fuquan also mentioned about gem classification. In 1980, Zhao Yongkui in Brief Introduction of Jades divided stones for craftsmanship into: gems; jades and colour stones. We can see that the present domestic classification tends to be more or less the same.

Summarizing the classification situation of gems and jades at home and abroad, we once classified the gems and jades of Xinjiang into two main groups in Development of Geological and Technological

work of Gems and Jades in Xinjiang: gemstones and colour stones. Now, according to the development of research work, the development trend of gems and jades, and the habitual names of our country, we divide Xinjiang's gems and jades into two main categories: gems and jades.The principle and concept of classification are as follow:

Gems: Monocrystals or crushed pieces that are monomineral, lustrous (possess the lustre of diamonds and glass), sparkling and crystal-clear, have bright colour, a high dioptre rate, a high degree of hardness (generally 7 in Moss hardness), a stable chemical nature, and satisfy the technological demands of gem processing.

In Xinjiang, the narrow sense of gems means especially diamonds, rubies and sapphires; the broad sense means presently gems that reach the level, like citrines (topaz), tourmalines, beryls, garnets, amethysts, purple apatites and precious spodumenes.

Jades: bright colour (possess different bright natural colours), a delicate texture, hard, the degree of hardness is large, a high reflexibility after polishing, translucent to transparent, the aggregate of one mineral or one main mineral, usually aphanitic structure of felt or fabrics and satisfy the technological demand of gem processing.The words gems and jades have a great difference in implications under various situations. In Xinjiang, the narrow sense of gem and jade means especially nephrite, Hotan Jades and jasper. The broad sense includes many rocks and mineral aggregates that satisfy the technological demands, such as Kunlun jade, lilac purple jade, agates, hair crystal, wax-yellow jade and Tekes green jade.

The classification of gems: We take gems as the main group and divide sub-groups according to the mineral names, like beryl and garnet, etc. It is again sub-divided according to the most outstanding feature of the technological demands (such as the colour feature) to several varieties. For example, tourmalines can be divided in different colours of double peach red, pink, purple green, blue, yellow and colourless.

The classification of jades: We take jade in the broad sense as a main group, and divided it into sub-groups according to the rock or mineral name, such as nephrite and agate, etc. Finally different varieties are divided according to the features of technological demands. For example, nephrite can be divided into sheep grease jade, white jade,grey jade, black jade, yellow jade and green jade according to the colour.

The name of gems and jades: The gems and jades of our country have various names, the mineral name, the technological name, the ancient name, the product name, the image name, the borrowed name, the pseudonym, the foreign language name, the synonym, place name, colour name and function name, etc. Engineer Luan Bingao estimates that altogether there are about 700 types of name, and there are about 70 types of names for gems and jades in Xinjiang. We can easily understand them if we get hold of the type of mineral and rock they belong.

Although gems and jades have various names, there are only two on the whole, they are: the name of the mineral or the rock, and the technological name. In the geological field at home or abroad, the mineral name is commonly used, and the technological name is used in the field of technology. In order to make up each other's deficiencies, a "dual name" should be adopted at the present situation.

According to the above fixed regulations, we list the varieties of Xinjiang's gems and jades below:

1. Gems

Sub-groups of Gems		Varieties of Xinjiang's Gems
Mineral and rock name	Technological name*	Type name
Corundam	Precious Corundum	Ruby
	Ruby	Sapphire
	Sapphire	
	Sese	
	Bizhu	
Garnet	Garnet	
	Almandine	Almandine
	Californite	Spessartite
	Cinnamon stone	Grossularite
	Demantoid	Cinnamon stone
	Topazolite	
Topaz	Citrine	honey-yellow topaz
	Yellow gem	rose topaz
	Topaz	blue topaz
Beryl	Beryl	Aquamarine cat's eye
	Aquamarine	Aquamarine, Greenberyl
		Golden beryl
	Zhumule	Rose beryl
	Qumolan	Colourless beryl
		Water bladder beryl
Spodumene	Precious spodumene	Jade green spodumene
		Yellowish green spodumene
Tourmaline	Tourmaline	Double peach red tourmaline
		Peach red tourmaline
		Blue tourmaline
	Bixixi	Green tourmaline
	Bixiaxi	Yellow tourmaline
		Purple tourmaline
		Black tourmaline

Apatite	Purple Apatite	Purple Apatite
Quartz	Amethyst	Amethyst
Microcline	Amazonite	Amazonite
Diamond	Diamond	Diamond

2. Jades

Sub-group of Jades		**Varieties of Xinjiang's Jades**
Name of rock or mineral	Technological name	Type name
Nephrite	Hotan jade	Sheep greasy jade,White jade Grey jade, Grey and white jade Black jade Yellow jade Brown sugar jade
	Jasper	Black and white agate Jasper Gold-mountain jade
Serpentine	Serpentine	Kunlun jade New pit white jade Serpentine jade
Lithina mica	Lilac Purple Jade	Lilac purple jade
Quartz	Rock Crystal Crystal stones Water jade Water quintessence	Colourless crystal Tea crystal Hair crystal Bristle crystal Citrine Amethyst Rose Quartz
Secondary quartzite	Aventurine	Green Aventurine Meat-coloured Aventurine White aventurine Beijing white jade

Siliceous slate	Yellow clay jade	Tugu jade (Yellow clay jade)
Turquoise	Turquoise Turkey jade	Turquoise (Turkey jade)
Chalcedony	Agate Qiongyao (Beautiful-jade)	White agate, Red agate Yellow agate Blue agate Black agate Ghost-face grey agate Sardony agate Onyx agate Lace agate White-thread black agate Bamboo-leaf agate Firewood-shape agate Schiller agate
Sodalite	Sodalite	Sodalite
Malachite	Malachite	Malachite
Chrysocolla	Chrysocolla	Chrysocolla
Plagioclase	Dushan jade	Dushan jade
Plagioclase diopside-diorite		Tekes green jade
Dolomitic marble	Wax-yellow jade	Wax-yellow jade
Ferruginous jasperite	Jasper (sheep liver stone)	Jasper (sheep liver stone)
Minor graphic pegmatite		Minor graphic stone

* *Above technological names are quoted from the Classification and Identification of Gems and Colour Stones, No. 1 Beijing Geology, 1979, by Luan Bingao*

Chapter Three Gems

Section One Beryl

I. General Account

The mineral name of beryl is also beryl, orignated from Greek.

Beryl means all the beryl crystals and pieces that have a brilliant colour, a good transparency and a bright lustre.

Xinjiang's rare metals – muscovite and crystal minerals, are famous all over the world. Beryl is one of the main types of Xinjiang's rare metal minerals. When studying the mineral deposits of rare elements in Altai of Xinjiang, we had a rather systematic study on gems and jades that are related to rare elements deposits. In China, it is the first time to discover aquamarine Cat's eye.

Xinjiang's beryls are found just in granite pegmatite and pneumatogenic – hydrothermal deposits of beryllium and the related placer deposits.

After carving, beryls become plain crown facets in forms of trapeziums, rectangles and rhombus and can be made into rings, earrings and ornaments like heart-shaped pendants.

Aquamarine, a type of beryl, symbolises courage, bravery and calmness in foreign countries and is praised as the "gem of bravery". It is listed as the birthstone of March.

II. Physical and Chemical Properties

1. Physical Properties

Beryl belongs to hexagonal crystal, usually in hexagonal column shapes and bipyramid shapes. The surface of the pyramid is usually not well developed and forms the so-called hexagoned truncated pyramid. Commonly seen are those in slate crystal plank shape, block and other irregular shapes.

The colour of the mineral changes according to the pigments contained. Commonly seen are different hues of green, blue, golden-yellow, yellow, white, rose. Colourless and their interim colours, of which the commonest are green blue and rose. It is generally believed that to have a bright colour is one of the conditions of a gem.

On the whole, beryl has the lustre vitreous, a very minor part of them have the resinous lustre. They are irregular at the cutting, some of them have shell-shaped cutting, with hardness 7.16 – 7.65 (actual measurement), specific gravity 2.5928 – 2.9931 (micro-gravity) and a brittle nature.

2. Optical Properties

Beryls are colourless and transparent under a microscope uniaxial crystals, negative (Optics) interference colour is from grey to yellow. The refractive index has obvious change according to the different colours of the mineral. According to our study, the refractive index of those that have different hues of green in granite pegmatite is the lowest, second are those with different hues of blue, and then the white, and the highest are those rose in colour. The change of the refractive index of beryls in pneumatogenic hydrothermal deposits of beryllium is not much.

The refractive indices of different kinds of beryls (see chart 1).

Chart 1 The refractive indices of different kinds of beryls.

Kind / Dioptrerate	Beryl	Golden-Yellow Beryl	Aquamarine	Rose Beryl
No	1.572	1.572	1.577	1.589
Ne	1.566	1.566	1.569	1.581
No-Ne	0.006	0.006	0.008	0.008

3. Chemical Elements and Chemical Properties

Beryls are not dissolvable in acid and the chemical properties is stable.

Chemical elements (see chart 2)

Chart 2 Chemical elements of different beryls

Name of gem	Elements (%)													
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	BeO	MnO	Mgo	CaO	Na_2O	Li_2O	*	H_2O^+	H_2O^-	Total
Aquamarine	64.40	18.52	0.35	0.01	12.78		0.13	0.20	0.91	0.26	0.05	2.38		99.99
General beryl	64.16	17.84	0.84	0.01	12.48	trace	0.21	0.28	1.54	0.36	0.19	2.30		100.21
Golden/yellow beryl	64.31	18.71	0.64	0.03	13.98	0.01	0.08	0.18				2.22		100.61
Pure beryl	63.60	18.53	0.16	0.02	11.74		0.07	0.18	2.43	0.78	0.44	2.44		100.39
Rosy beryl	63.65	17.54	0.08		11.37	0.007		0.23	1.60	0.97	2.84	lgn. loss 1.97		100.257

* = $K_2O + Cs_2O + Rb_2O$

Besides, there are other trace elements: niobium, gallium; germanium; bismuth; molybdenum; silver; copper; yttrium; ytterbium; scandium; lead; zinc and vanadium.

III. Types of Beryl

Beryls of different kinds of formation in Xinjiang can be treated as a gem if they conform the following conditions: completely transparent, no cracks, slight veins of floss, impurities, no irregular colour or slight flaws. Beryls in Xinjiang can be divided into five groups.

1. Aquamarine and Aquamarine Cat's Eye

Because blue beryls have different shades of colour, like aquamarine and turquoise, people call the latter as aquamarine. Aquamarines in the region of Xinjiang are 1mm thick, under the SE ray, working voltage 517V, under the condition of a 10 fold objective lens. the actual measurement of colour index of the direction N' the visual transmissivity is: V=68.4438; colour coordinate: X=0.3412, Y=0.3315; main colour wave length: $\lambda\alpha$ =541; colour pureness: Pe=0.069. It can be divided into transparent and translucent according to its degree of transparency. Those that are transparent are more precious gems (aquamarine) (colour photograph 5), and the price is higher; those that are translucent are comparatively inferior. Aquamarines, in general, are crystals in hexahedronal shapes and in block, the sizes is relatively large, from several cm to more than 10cm long, with a diameter 0.5 – several cm. Up till now, the largest aquamarine crystal found in the region of Xinjiang, the single crystal, weighs about 1.5 kilo. The specific gravity of aquamarine is 2.704.

Not long ago, a kind of rare aquamarinic Cat's Eye was found in the Altai region of Xinjiang (colour Photograph 6). Aquamarine Cat's Eye is a transparent crystal aquamarine in colour. If used to process a kidney-shaped plain crown facet, a bright ray belt, like a cat's eye, will move about according to the direction of the incident ray or the turning of the gem. As a result, it is called " you cai" or "qian cai" in Chinese and is a rare treasure in that kind of gem.

According to our observation of the formation of the cat's eye, it is related to the directional arrangement of inclusion in the gem. When a gem having this kind of inclusion is carved into a curve shape, it can still produce a concentrated and powerful reflex to light, and can produce a concentrated and powerful reflex to light, and can change and move about along with the direction of the incident ray.

Aquamarine is mainly produced in granite pegmatite during the period of Variscian, besides, in the granites of pneumatogenic-hydrothermal beryllium desposits, during the period of Yenshan movement.

2. Golden Yellow Beryl

Golden/yellow beryl has different colours like golden yellow, honey yellow (colour photograph 7) and yellow with greenish tints. Honey yellow beryls are 1mm thick, under the SE ray, working voltage 517 V, under the conditions of a 10 fold objective lens, the actual measurement of colour indices the visual transmissivity: V=82.7135; colour coordinate: X=0.3617, Y=0.3719; main colour wave length: $\lambda\alpha$

=579; colour pureness: Pe=0.2412. The crystal is usually smaller, individual 3×10 – 4×10 – 15cm. It is completely transparent, its specific gravity 2.80. Its production is relatively less, and belongs to the group of more precious gems and is highly looked upon. It is mainly found in granite pegmatite during the later period.of Variscian.

3. Green Beryl

The colours of green beryl are dark green, dull green, light green (colour photograph 1, 2, 3, 4), green with yellowish tints, etc. This kind of green may not be caused by chromium ion,but by venadium and ferric oxide, and is between emerald and golden yellow beryl. The crystal is on the whole 10×15 – 8×10cm, some as heavy as 620 gram, and is transparent and clear, with no flaws and is generally popular. Its specific gravity is 2.708. This kind of beryl is more commonly seen in Xinjiang, and is produced in the crystal cave of granite pegmatite during the later period of Varisian.

4. Rosy Beryl

The colours of rosy beryl are rosy and pink, and are mainly caused by alkaline metal ion Li, Cs, Rb, etc. It is usually in short column shape or plank shape, the size is about 5–10 × 1–2cm. Those that are transparent and clear are rare. It has the lustre of grease and its specific gravity is 2.756. This kind of beryl is found in the combination of Lithium and cesium section, in the granite pegmatite, during the later period of Varisian.

5. Pure Beryl and Water Bladder (Shui Dan) Beryl

The kind of beryl that is colourless and as transparent as water is called pure beryl (colour photograph 8). It is produced in hexahedronal column shapes and block has the vitreous lustre and is as transparent as water. The general size is 3–10×0.5–5cm, the largest being about 8 kilo. In certain pneumatogenic hydrothermal–beryllium deposits in Xinjiang, the crystal of water bladder(shui dan)beryl are found. One can observe the movement of the inclusion liquid inside the crystal, and it is considered as the rarest treasure of this kind of gem.

Pure beryl and shui dan beryl are mainly produced in pneumatogenic hydrothermal beryllium deposits and granite pegmatite, replaced aggregate in the stage of Lithium and cesium, during the later period of Varisian.

IV. Technological Features and Requirements of Processing of Beryl

Beryl is a gem of medium grade. Based on practice, its demand is just that the colour is pure, with no irregular colour and a good transparency; there should be no cracks or just a slight crack, no impurities and the size can be processed to a crown facet.

In the light of observation, the brightest colour of Aquamarine appears in the direction of axis C of the vertical crystal, and the brightest colour of yellow beryl is observed in the direction of axis C of the parallel crystal. As a result, the precise crystallizing position of the gem must be chosen before processing, so as to ensure the brightest colour of the product and raise its value.

V. Appraisal Features of Beryl

Beryl is easily confused with tourmaline, but they can be distinguished from the colour, shape and skins of cracks.

The colour of aquamarine is always light blue and is rarely rich, but blue tourmaline has rich colour ones.

Colour shapes – There is no obvious colour for aquamarine. Blue tourmaline sometimes has the colour shapes of a heart shape or a hexahedronal shape, or the colour appears to be in the distribution of an interior state, that is, within a crystal, the colour of one side is rich, the other is light, or one side is red, the other is blue, or the inside is red, the outside is blue.

Characteristics – the characteristics of the skeins of blue tourmaline is not often possessed by aquamarine. Aquamarine and some beryls sometimes have air liquid inclusion distributed in layers in the vertical axis of c.

VI. Geological Features of Beryl's Origin

Xinjiang has a wide distribution of beryl's mineral deposits. Probing into the cause of formation, it can be divided into five types: granite, granite-pegmatite, pneumatogenic hydrothermal,hydrothermal and external placer deposits, out of which only three can form the deposits of beryl: the type of granite-pegmatite , pneumatogenic hydrothermal and placer deposits.

1. The Granite-pegmatite Type Deposit

According to the features of origin, the granite pegmatite deposit containing beryls can be divided into miarolitic-pegmatite and hollow blastula pegmatite.

Miarolitic-pegmatite

In the region of Altai in Xinjiang, the cause of formation is related to refusion or granitization. A great number of pegmatite veins had been produced during the late period of granitization, and is distributed in the surrounding of granite's top. It is controlled by the regional structure mostly appeared in the axis of the anticlinorium, wings and plunging ends. The pegmatite related to refusion granite is distributed in its surrounding. This kind of pegmatite is in veins shape and lens shape, some are produced in tube shape. In the centre of the vein where there is a quartz pillar, or at the expansion of the vein, there are some relict cave or miarolitic cavity. In these caves, very often, there are aquamarines, pure beryls and green beryls of fine quality produced. The gems have different varieties, the size of the crystal is large and the minerals have a good transparency. Its mineral intergrowth are cleave landite, quartz and muscovite. These gems are the by-products collected when mining rare metals and muscovite.

Gem deposits of this type are distributed in U.S.S.R., U.S.A., Brazil and Madagascar.

Hollow-blastula Pegmatite

It is mainly distributed in the east and west Junggar area in Xinjiang. The veins of pegmatite are mainly produced in the interior part or edge of big granite. Pegmatites containing minerals are usually in shapes of equal axis, a small amount of them are prolonged veins and steeper. This kind of pegmatite is generally in good differentiation, with the development of graphic pegmatite zone, block microcline zone, quartz core.Usually big miarolitic cavity occurred in this kind of pegmatite.It is mainly distributed under the quartz core. This hollow-blastula miarolitic cavity is just the place provided for the mineral

freely growing and crystallizing a comparatively large crystal was once found. The single crystal weighed about 1.5 tons.Intergrowing with quartz crystal are green fluorine topaz in rose, colourless, light yellow and blue, amethyst, less aquamarines and green beryl, this type is bright in colour and has a good transparency. Hollow-blastula pegmatite is also produced in U.S.S.R.

2. Pneumato-hydatogenetic Beryllium Deposits

At present, the known pneumato-hydatogenetic beryllium deposits are mainly distributed in the Altai region in Xinjiang, and are greisens containing beryls. These greisens were distributed at the top of granite during the period of Yenshan movements. The granite of this period injected into the gueiss-biotite granite of Varisian as a cupola shape. The deposit is made up of a metamorphic granite body, veins of pneumato-hydatogenetic pegmetite, A placer deposit. The metamorphic body consists of three metamorphic zones. The grain size of the beryl is smaller among the metamorphic granite zone 0.3 — 0.8mm. Some of them may be 1.5-2mm. It is xenomorphic or hypidiomorphic texture. it looks nearly round in shape. The mineralize of the beryl is very weak among the metamorphic zone of the pegmatite. The beryl in the striped metamorphic zone is in green colour. In column shape or radiating. It is less than one cm in length, several millimeter in diameter.

Pneumato-hydatogenetic vein is the zone where beryls have the strongest crystallisation, and is made up of the two zones from interior and exterior. The interior zone is the zone of quartz in block, in which beryls are light blue, light green in colour, and in hexagonal column shape, the size is usually 5-30cm long, diamter 1-10cm; the exterior zone is beryl – quartz – muscovite zone and rich of beryls. The colours are from light blue and light green to deep blue and deep green. The crystal is usually in complete hexagonal column shape. Beryls are mainly produced in this zone. The varieties are aquamarine, green beryl, pure beryl and shui dan beryl. Its mineral intergrowth are quartz, muscovite, microcline, apatite and spessartite.

In the Outer Baikal region of USSR, there are typical pneumato-hydatogenetic type of beryl deposits. This kind of deposit is mainly related to greisens of wolfram and bismuth. Valuable aquamarine aggregates are mainly produced in the crystal cave.

3. Placer Deposits of Beryl

At present, the beryl placer deposit is just seen at the foot of the above pneumato-hydatogenetic beryllium deposits. The placer deposit is formed by the corrosion of glacier. Its material constituents are basically the same as the autothonous rock from the original place. The accumulation is divided into three layers, from top to bottom, according to the constituents and size: the surface is the layer of bricks and stones, the middle layer is sand and the bottom sand, crushed stones and bricks. Among them, the bottom is the main layer that contains minerals. The beryls in that placer deposit are aquamarine, green beryl and pure beryl. The gems are mainly in pieces, a small amount in hexagonal column shape. The size is comparatively small but the quality of beryl is good on the whole.

In Ukraine of Soviet Union, Brazil and Madagascar, the remaining placer deposits of aquamarine are produced.

VII. Utilization Value of Exploitation

Beryl is the good-looking one among the beryl group. Granite pegmatites are widely distributed in Xinjiang. Its richness in various kinds of colourful beryls leads to a bright future for the exploitation of beryl, especially after the discovery of aquamarine Cat's eye, the economic value has been raised.

Section Two Tourmaline

I. General Account

Tourmaline as a gem can first be seen in the writings of the Qing Dynasty in our country. It was called "Biyasi", or "Bixi" in the Decrees and Regulations of Qing Dynasty (Qing Hui Dian Tu), "Bixiaxi", "Bixiapi" or "Bix" in Firm Willpower as Filling up Seas (Tian Hai Yu Heng Zhi) and "Bixiax" in The Record of Jade (Yu Ji), in which the pink one is called "the child's face".

In USSR tourmaline is called "Siberia Gem" and "Siberia ruby" for the pink one.

Tourmaline was a more precious gem before. It was said that among the sacrificial objects of Empress Dowager in the Qing Dynasty,there was a tourmaline lotus flower at her feet.It weighed 36.8 taels , at the value of 750,000 taels of silver.

Tourmaline is a gem of medium grade named tourmaline in mineralogy. In the early sixties, a lot of colourful tourmalines were not noticed while mining and processing rare metals and muscovite and only a few geologists and miners collected it as specimen. In Altai area, later was identified as a kind of gem in Xinjiang on the basis of our studying. It was not until that tourmaline and other gem raw material has been utilized and well received abroad.

II. Chemical and Physical Properties

1. Physical Properties

Tourmaline belongs to the trigonal system appears generally in ditrigonal prism. Long prism or needle crystal, fracture, spherical triangle, longitudinal striation on the prism surface.

Because of the difference of trace elements contained in tourmaline, there is a diversification of its colour. It is generally considered that black tourmaline is of iron type, brown tourmaline magnesium type, and the so-called polychrome tourmaline is red, green, yellow, blue, purple and colourless and of alkaline metal type. The multicolour tourmalines commonly seen in granite pegmatite in the region of Altai in Xinjiang are mainly blue, green, colourless, rosy, pink and purple apart from black. Something interesting is that in the same piece of crystal, the centre part is rosy in colour(colour photograph 9), the edge is green or blue and the outer circle blue; some of them have more than three colours in a piece of crystal; and there are some with one end rose in colour, another colourless and green (colour photograph 10.), and it is what they call string colour tourmaline. (colour photograph 11).

The hardness of tourmaline is 6.43-7.25, and the specific gravity 2.917-3.142 (method of density bottle). The mineral is transparent translucent, irregular at the cutting, with a brittle nature. Tourmaline has the lustre of caking electricity glass, a weak magnetism or no magnetism. It has piezoelectricity as well.

It is common to see inclusion in tourmaline. In green tourmalines, actinolite inclusion.

2. Optical Properties

Tourmaline belongs to uniaxial crystal (–) negative.

Its actual measurement of refractive indices is: Ne=1.626–1.640, No=1.640–1.658; its double refraction is No – Ne=0.014–0.018. Its polychrome absorbing power is obvious, and its colour has an obvious change with the difference of the colour of mineral: black tourmaline, Ne dark brown, No blue; blue tourmaline, Ne colourless – light yellow, No light blue; green tourmaline, Ne light yellow, No light yellowish green; colourless and rosy tourmaline, Ne colourless, No colourless – light yellow.

Here is a chart on the contrast of the specific gravity and refractive indices of multicolour tourmalines that are produced in Xinjiang and USSR.

Chart 3 A chart on the contrast of refractive indices and specific gravity of multicolour tourmalines

Kinds / Occurrence / Properties		Black Tourmaline		Green		Blue		Red	
		Xinjiang	USSR	Xinjaing	USSR	Xinjiang	USSR	Xinjiang	USSR
Refract-tive index	Ne	1.6370	1.628 ~1.633	1.630	1.613 ~1.628	1.6245		1.6220	1.616 ~1.624
	No	1.6660	1.658 ~1.668	1.645	1.637 ~1.648	1.6440		1.6440	1,634 ~1.642
Specific gravity		3.2425	31. ~3.2	3.0569	3.047 ~3.075	3.058		2.9822	3.012 ~3.049

3. Chemical Elements and Chemical Properties

The chemical elements of tourmaline can be represented by the following chemical formula: $Na(Mg, Fe, Ca, Mn, Li, Al)_3\ Al_6\ [Si_6\ O_{18}]\ (Bo_3)_3\ (HO.F)_4$. Among them, magnesium (Mg), iron (Fe), maganese (Mn), Lithium (Li) and aluminium (Al)can be inter-replaced, and Lithium and aluminium can be replaced by other alkaline metal, and thus showing different colours.

According to the studies of Liu Guobin et al, the formation of the "Watermelon" tourmaline in the region of Altai in Xinjiang can be divided to two stages: the first stage is rapid growth under the environment of no iron, leading to the formation of a rose inner nucleus that possesses a macroscopic setting structure. The second stage is to be, for a short time, in a solution lower than the level of saturation and which is rich in iron, so as to impel the growth of blueish green at the outside edge. This kind of monochromatic tourmaline is formed mainly in rapid growth for once. When crystallization takes place, the solution that is rich in iron and that which is lack in iron appear alternately, and do not overlap in certain limits, and as a result, tourmalines of one single green or one single rose are formed. Otherwise, tourmalines of horizontal colour belt will be crystallised.*

The indication of some polychrome tourmalines' visible light absorption spectrum in the Altai region's granite pegmatite by Lilu Guobin et al.:,rosy tourmaline (red tourmaline)'s highest absorption is 19500cm^{-1} this wide belt is the permitted transition absorption summit of Mn^{3+}. Besides, there are two weak narrow absorptions, 22300cm^{-1} and 21900cm^{-1}, that can be absorbed by Fe^{3+}. Because the permitted transition absorption (14000cm^{-1}) of Fe^{2+} is weak, the absorption of Mn^{3+} and Fe^{3+} become the main cause of colour formation of rosy and pink tourmalines. The absorption spectrum of indigo-blue tourmaline is more complicated, the highest absorption is at 14000cm^{-1}. The absorption of indigo-blue tour-

maline is stronger than that of the colour of yellowish green and rosy. It shows that the Fe^{2+} content is high and Fe^{2+} is the main factor of indigo-blue tourmaline's colour formation. The absorption spectrum of yellowish green tourmaline is different from the above two kinds of tourmalines. It is combined by a permitted transition zone of Fe^{2+} at around 14000cm^{-1} and a straighter absorption edge, and is outstanding in ETC spectrum. That absorption edge is the voltage transfer spectrum of Fe and O, and the voltage transfer spectrum has a great effect on the green and yellowish green of tourmalines. (Figure 1).

The experiment of Musbor spectrum of tourmalines shows that the Fe^{2+} of indigo-blue tourmalines does not only occupy the octahedron shape on the position Y in the crystal structure, but also that on Z. The latter is through the exchange of $Fe^{2+} - Al^{3+}$. (Figure 2)

The studies of infrared absorption spectrum (Figure 3) of tourmalines of different colours show that rosy tourmaline has an obvious difference from other variants containing iron. Those that are blue, green to black have closer infrared absorption spectrum. As the flexible vibration of (OH) (3300-3600cm^{-1}absorption belt), rosy tourmaline shifts obviously towards the direction of short wave. In the absorption belt of 700-785cm^{-1} represented by B-O winding vibration, rosy tourmaline lacks the 750cm^{-1} summit commonly seen in other tourmalines containing iron. Similar situation happens in the main absorption belt (780-1100cm^{-1}) of Si-O flexible vibration, because part of Si is exchanged by Al and thus Al-O vibration appears. It shows that the using of rosy tourmaline, which is low in iron and rich in aluminium, still shows the slight difference from other tourmalines in structure on the infrared absorption spectrum.

The chemical nature of tourmaline is stable and will generally not be eroded by acid and alkaline.

*Liu Guobin and Guo jiugao: An Initiative Research of Formative Process and Colour Origin for Tourmaline with Belt in Xinjiang.

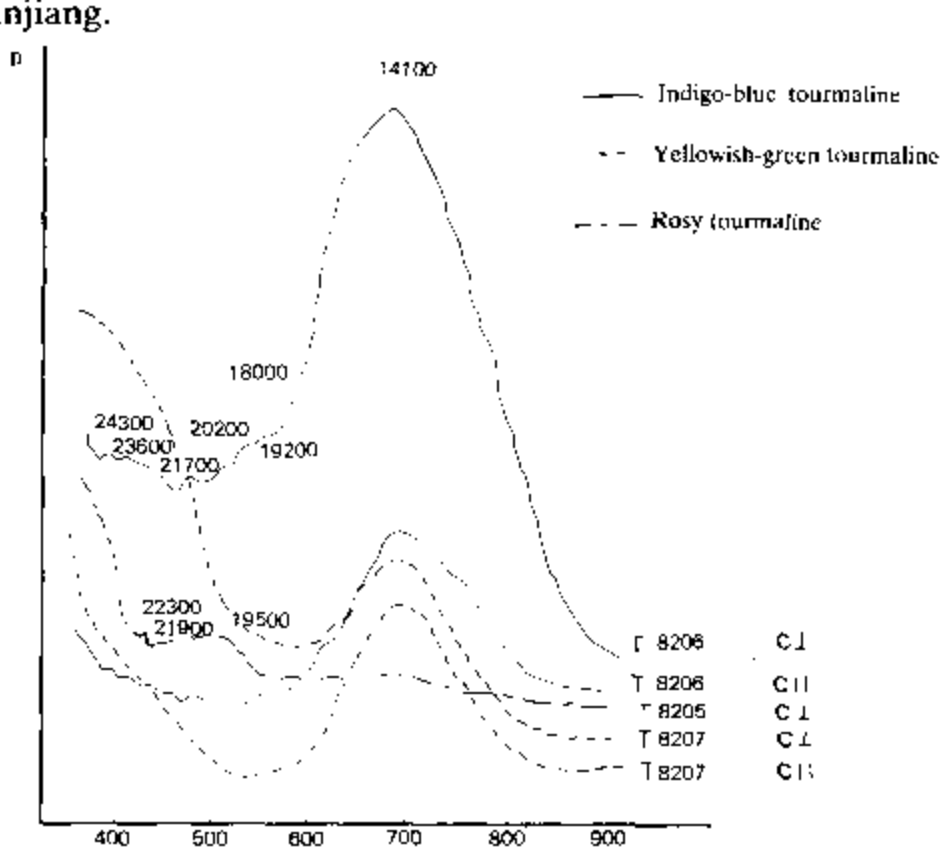


Figure 1 The absorption spectrum of polarisation of polychrome tourmaline.

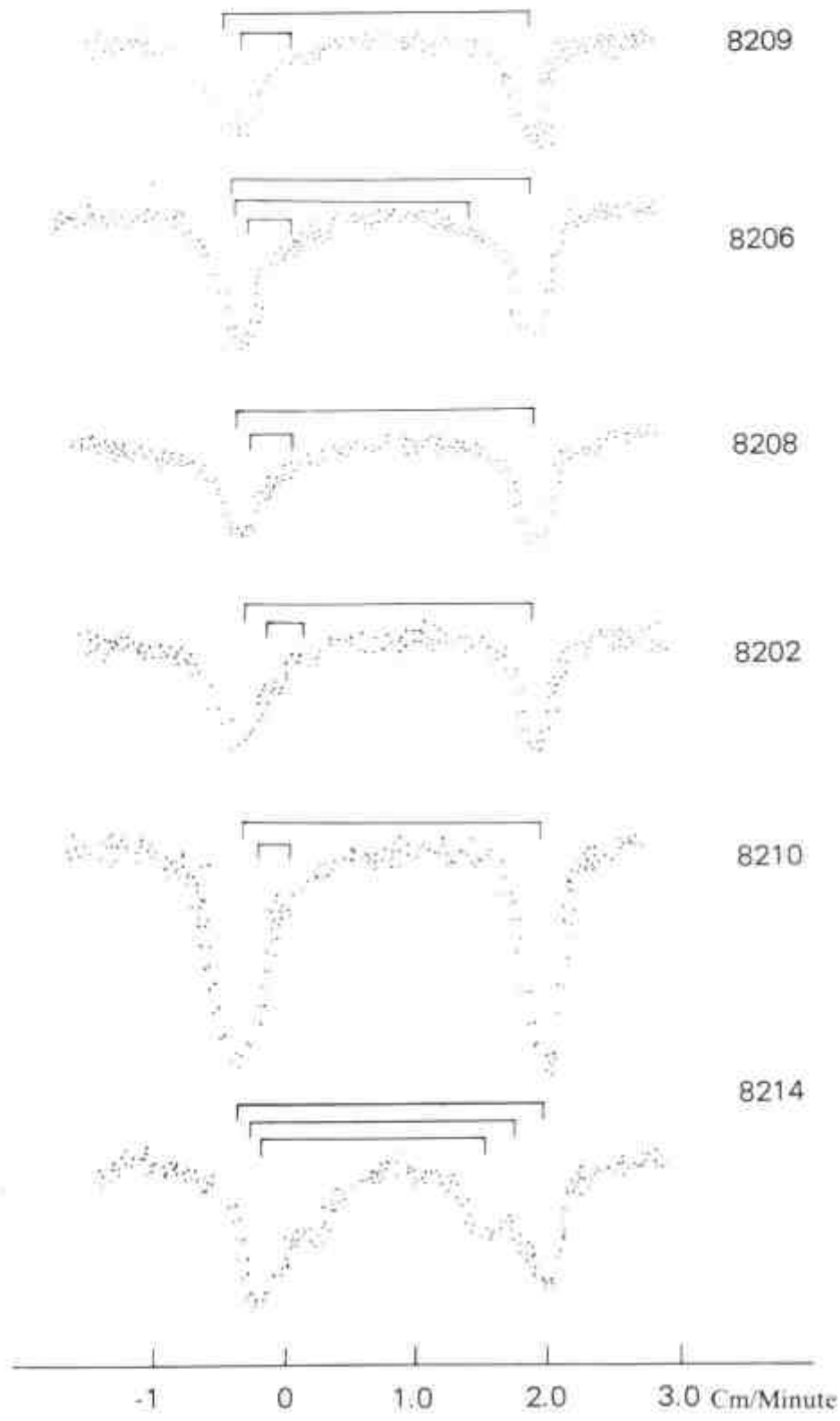


Figure 2 The Musbor spectrum of tourmalines

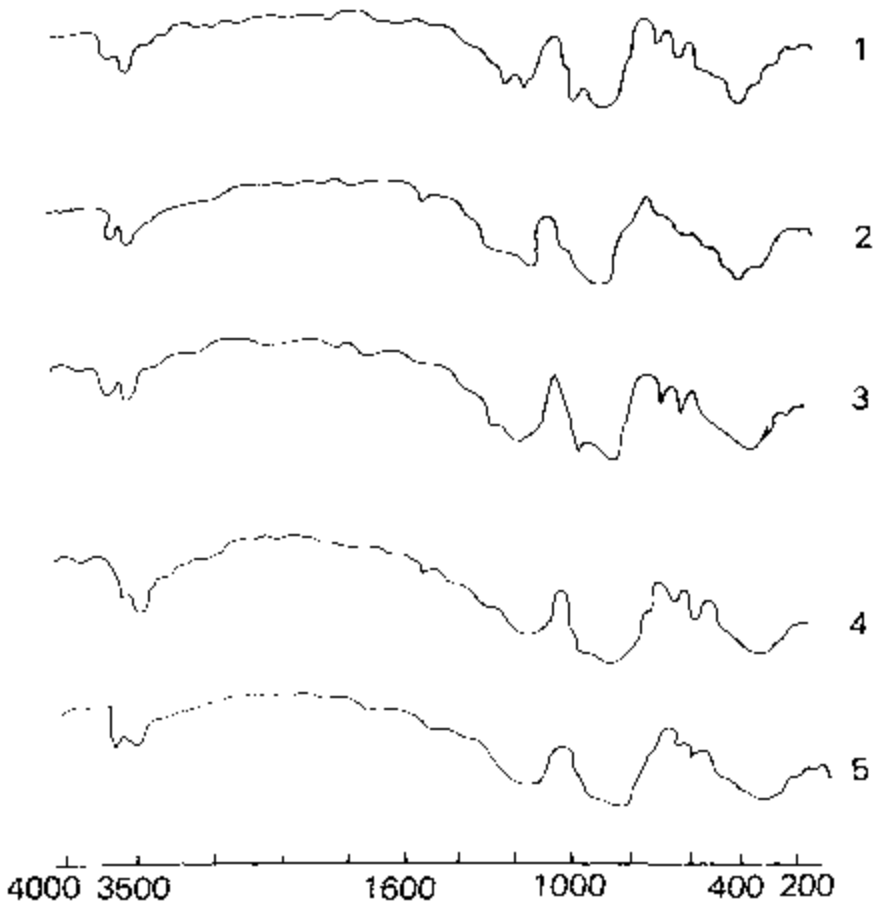


Figure 3 The infrared absorption spectrum of tourmaline of different colour (1) rosy tourmaline (2) yellowish green tourmaline (3) green tourmaline (4) black tourmaline (5) indigo blue tourmaline

Chart 4 The characteristics of the chemical elements of several main tourmalines according to the related information the content of the chemical elements of several main tourmalines as in chart 4.

Kinds of Tourmaline		Content of the chemical elements (%)					
		MgO	$FeO+Fe_2O_3$	Li_2O	F	MnO	Al_2O_3
Black Tourmaline		0–10	10.7–15.0			0–1.0	34–36
Magnesium Tourmaline		11.0–15.0	0–10.0			1–1.36	35–39
Lithium Tourmaline	red and colourless	0.02–1.82	0.11–1.0 few reach 2.1	0.11–1.92	0.13–2.6	0.11–2.04	38.9–44.4
	green and blue	0–2.0	1.07–7.12	0.12–1.76	0.14–2.10	0.02–2.83	36.6–46.5

III. Technological Processing Requirements

Tourmaline is a gem of medium grade. First rosy is generally the best colour, then, pink, and at last, the other colours. As a gem, the mineral must be completely transparent or translucent, with no cracks, no impurities or the impurity is not serious. It must be more than five grams, or the diameter of the crystal's cutting is more than 8mm, so as to be technologically processed.

The technological utilization of tourmaline depends on its size, colour, transparency or flaws. Usually multicolour tourmalines are carved into petals or plain crown facets as jewels. Larger ones are carved into heart-shaped pendants, smaller ones for ear-rings. In the past, they were made into hat ornaments, court beads and stirrup ornaments. Those that were of inferior quality, like black tourmaline, can just be used as the material for jade carving, and be carved into potted landscapes, like those displayed in the Palace Museum.

IV. Types of Tourmaline

Among the tourmalines that are used as gems or jade carving in Xinjiang, they can be divided into 6 types according to their features like the brightness of their colour, their transparency, the amount of cracks, their flaws and their sizes (the size of the crystal), etc.

1. Green Tourmaline

The colour is light green, blueish green (colour photogragh 12) and yellowish green. According to the experiments of the absorption spectrum, its colour is caused by Fe^{2+} The diameter of the cutting of the mineral crystal is 0.2-1.5cm, 3-5cm long. The largest found in the region of Altai in Xinjiang weighs about 325gm. Green tourmaline is the main type of tourmaline.

2. Red Tourmaline

The main colours are pink and rosy (colour photograph 10). According to the study of the absorption spectrum, the appearance of the colour is related to Mn^{2+}. Some red tourmalines have the outer circle in dull green, the centre in pink, or the outer circle in black, the inner in pink. On the whole, they are transparent completely, some are translucent. The quality is good, few of them have flaws. Generally the diameter is 0.5-2cm, some reach 5cm, and are 3-8cm long. Double pink tourmaline is a treasure in tourmaline.

3. Yellow Tourmaline

Golden yellow or honey yellow are special products of some regions in Xinjiang. They are completely transparent and have the lustre of glass. Usually the size is not big, with the diameter 0.5cm and length 2-3cm.

4. Purple Tourmaline

Purple tourmaline is transparent. The longest diameter can reach 1.5-2.2cm. It is very good looking, and is a gem of good quality and rare.

5. Tourmaline

It is colourless and transparent as water, and is also known as common tourmaline. The size is usually not large, with a diameter 0.2-2cm, and length 3-8cm. There is not much flaw or crack. The value is not as precious as the above four kinds of tourmalines.

6. Black Tourmaline

Dull black or brown (colour photograph 13), translucent, and have longitudinal striation on the surface of the crystal. There is a great difference in the size, the largest is as long as 40cm, with a diameter of 20cm. This kind of black tourmaline cannot be treated as a gem but the material of jade carving.

V. Appraisal of Tourmaline and Other Similar Gems

1. Yellow Tourmaline,Citrine and Peridot

The colour of yellow tourmaline is clear yellow with a greenish tint, and it gives a sense of tenderness; citrine is golden yellow in colour and is dark and old. The skeins of tourmaline generally stands perpendicular to the column surface of the crystal, and there are streaks parallel to the column surface; citrine does not have this feature.

Yellow tourmaline has colour form usually has the concentric hexagon but peridot does not have this feature.

2. Blue Tourmaline and Aquamarine

The colour of blue tourmaline is darker while that of aquamarine is lighter. Blue tourmaline has fixed colour form and concentric hexagon, one end is darker, the other is lighter, or one end is red, the other blue. Aquamarine does not have this feature, and possess air – liquid inclusion distributed in the form of layers, and which stands perpendicular to axis C.

3. Red Tourmaline and Rose Quartz

The transprency of red tourmaline is better than that of rose quartz, the surface of the spherical triangle or the hexagonal column can be seen, the interior has the hair-like character; rose quartz appears in pieces, and is shell-shaped at the cutting.

4. Green Tourmaline and Emerald

Green tourmaline is blueish green, yellowish green and dark green in colour, but the colour is dull; the colour of emerald is bright and rich. Green tourmaline has the special character of hair, skeins that are vertical to the column; emerald has character of "cotton". When beryls have character of cotton, character of hair and its lustre caused are more obvious.

5. Tourmaline and Other Fakes

(i) Fired tourmaline: meaning the tourmalines that do not have a good colour and is artificially coloured. The skeins of these tourmaline increase obviously and it is obvious that the colour comes from the skeins inside, and it has a clear difference from the natural ones.

(ii) Blue glass: Synthetic glass has clear air cells and bubble, its colour is dull, the quality changes and it is easy to have dichroism. The specific gravity is low and the material is light.

(iii) Battle hair stripes: It is a kind of quartz glass that has added colour. It also has the characteristic of character of hair, which is concentrated and in order. The colour is even and artificial; character of hair of natural tourmaline has uneven densities in different length. It has a fixed shape of colour distribution and a clear difference from it.

VI. Geological Features of Tourmaline's Origin

The origin of most of the tourmalines that have good value is related to granite pegmatite, part of them is related to pneumatogenic hypothermal deposits of tungstuntion odre at a high temperature. The sodium-lithium type of granite pegmatite has a good differentiation and a strong metasomatism and produces different kinds of tourmalines. The following is an account on the origins of Xinjiang's various tourmalines.

Black tourmaline is mainly distributed in the large granular structure belt of granite pegmatite, clumpy structure and aggregates of the mineral replacement at their later stages. When the country rock is schist, black tourmaline in the contact is well developed. This can frequently found in numerous granite pegmatite veins in the areas of Xinjiang. Black tourmaline principally is in acicular and radiating aggregates distributed unevenly. It always intergrows with biotite, muscovite and garnet. It is formed in the course of contact metamorphic process.

Black tourmaline in coarse-grained texture belt always intergrows with oligoclase, microcline, perthite and muscovite. Crystal form is in short columnar shape. Its cross section is a near spherical triangular. There is flaky muscovite on its surface and sometime there is feldspar malformation crystal.

Black tourmaline in block structural belt appears to be a long prism form. It is mainly dispersed in cracks of quartz and feldspar and sometimes in quartz or microcline and constitute a pseudo graphic texture.

Black tourmaline in metasomatic aggregate is always intergrowed with quartz, oligoclase, garnet, beryl and muscovite, mostly in short prism shape, without fixed direction.

In a word, black tourmaline is widely distributed in the granite pegmatite dykes of crystallization-differentiation and poor metasomatism, small-scaled vein body, simple mineral composition and in better crystallization-differentiation and metasomatism, larger-scaled, more mineralized rare elements in granite's edge and other further fringes.

Colour tourmaline, that is various colours of tourmaline, commonly appears in better crystallization differentiation-poor metasomatism, larger-scaled, rare elements, especially the part of the granite pegmatite nearer the core of the strongly mineralized lithium (containing spodumene or lepidolite). These tourmalines are special products of the granite pegmatite at their later stages. This kind of granite pegmatite in Xinjiang develops widely colourful tourmaline, from rosy to green and blue colour, generally in prism shape. Sometimes, a crystal is in rosy colour in its core, green or blue on the fringes, or in red colour at one end, and colourless at another. Lithium and albite, etc. intergrow with those colour tourmaline.

Now, let us look at an example in a certain place in Xinjiang to illustrate the mineralization conditions of tourmaline.

The pegmatite vein is occurred in gneiss-biotite granite. Country rock is in gneissic structure, with

dip of 295°, dip angle 40-50°. The dividing line of country rock with rock vein is clear, and it is in regular slaty body. It is dozens of meters long, several metres thick on an average and elongates tens of meters more along inclined direction.

Rock vein is divided into five belts from the top to the bottom.

(1) Coarse pegmatite belt in upper wall is 0.3-0.5 meter thick, main compositions: alkali- microcline (70-90%) with white quartz (20%). Secondary minerals fragmental dolomite and starry garnet.

(2) Cleave landite metasomatic aggregate in upper wall draws a clearline with the upper and lower belt. It is 0.1-0.3 metre thick and 0.2 meter thick on an average. Almost composed of blue-green cleavelandite. The foliated longer size is at a cross angle of 50-90° with the surface of the belt, sub-minerals are few, sometimes, quartz, muscovite and garnet can be found.

(3) Central quarts – albite – lithionite metasomatic aggregate: The belt is complex in mineral components, main compositions are as follows: White-smoky quartz, foliated albite, cleavelandite, lithionite, alkali-microcline restite, caesium silicate, colour tourmaline, muscovite, alkali-beryl, apatite, montebrasite columbite-tatalite, sericite and spodumene and so on. Among them, caesium silicate appears in lens shape. This belt is not stable.

(4) Cleavelandite metasomatite aggregate of lower wall, which is the same as belt 2.Sometimes shinning out.

(5). Medium-grained pegmatite in lower wall: Mineral granule is smaller than those in belt 1. It is a little albitized near the belt 4. Short columnar black tourmaline is plentiful near the surrounding rock of lower wall, black tourmaline is no longer there at the dip of 25 meters, caesium silicate appears.

In this rock vein, colour tourmaline is produced in quartz – albite – lithionite metasomatic aggregate. Colour tourmaline in Xinjiang is generally produced in this kind of metasomatic aggregate. The ore finding place is very obvious.

VII. Exploitation of Utilization Value

Th various kinds of tourmalines in Xinjiang are all produced in granite pegmatite. Especially for the multicolour tourmaline, they are produced in the sodium – lithium type of granite pegmatite that is good in differentiation and strong in metasomatism. Tourmaline can be treated as a gem of medium grade, can be carved into decorations and handicrafts and is popular in the international market. Xinjiang still has several regions to be exploited and as a result it has a certain economic value.

Section Three Garnet

I. General Account

The mineral name of the gem garnet is called garnet. It is a class of mineral, and, according to its elements, two subclass and six groups can be divided. See chart 5

Chart 5 The mineral of the garnet class

Class	Sub-class	Group	Theoretical chemical formula
Garnet	Aluminium Garnet	Pyrope	$Mg_3Al_2Si_3O_{12}$
		Spessartite	$Mn_3Al_2Si_3O_{12}$
		Almondine	$Fe_3Al_2Si_3O_{12}$
	Garnet Calaium	Andradite	$Ca_3(FeTi)_2\ Si_3O_{12}$
		Grossularite	$Ca_3Al_2Si_3O_{12}$
		Uvarovite	$Ca_3Cr_2Si_3O_{12}$

It was said that the six groups of garnets can be used as a gem. And in Xinjiang, those have been used as a gem are spessartite and grossularite and can be carved into crown facets, heart-shapes and ear-rings, etc.

It was just in the recent years that spessartite and grossularite are used as a gem. The first to be utilised is spessartite. Grossularite was first found by the local peasants. In 1980, it was found by Xinjiang's geological workers when they were doing some investigation in a certain area. They gathered them as specimen and after examination, trial carving and sale, it was utilized and named as Altai emerald (green grossularite) and cinnamon stone (yellowish pink grossularite).

Gems of garnet symbolise faithfulness, fraternity and virginity abroad and is listed as the birth-stone of January.

II. Physical and Chemical Properties

1. Physical Properties

Garnet belongs to regular system, the forms of the crystal generally area mostly combinate form of the two dodecahedron {110}, tranpezonedran {211}. It's in the granite pegmatite or the skarns in the

contact metasomatism zone. It appears to be an irregular form or agregate, a few complete crystal forms.

The colour of garnets has an obvious difference according to different groups. Even from the same group, the colour varies greatly because of the different occurrence. There are mainly different hues of red, yellow, brown and green, and there are also black and white. The colour of the powder is light yellow and colourless. It has the lustre of glass and is transparent – translucent. There is not cleavage, uneven fracture, hardness 6-7, specific gravity 3.57-4.27 (actual measurement).

2. Optical Properties

Thin slices of garnet are colourless, light yellow and rosy isometric body under microscope, its refractive index 1.714–1.887. The X-ray analysis of powder crystal is to make use of the diffraction effects of x-ray on polycrystal powder to study the method of mineral's crystallization. To make use of the powder method may find the relative configuration in the random orientation $\frac{d\alpha}{n}$ and the diffracted intensity I. The x-ray analysis result of powder crystal of spessartite, grossularite and andradite produced in Xinjiang is listed in Chart 6. The formula in Chart 6 is basically the same as the standard formula, so are named spessartite, grossularite and andradite.

Chart 6 The analysis data of garnet under the X-ray powder method

Number	B003	Spessartite	Number	B004	Grossularite	Number	B001	Andradite
No	I	$\frac{d\alpha}{n}$	No	I	$\frac{d\alpha}{n}$	No	I	$\frac{d\alpha}{n}$
1	1	3.8661	1	2	(3.24)	1	2	4.22
2	1	3.3728	2	5	2.94	2	3	(3.31)
3	1	3.0874	3	3	(2.92)	3	7	3.00
4	7	2.8847	4	10	2.645	4	3	(2.97)
5	10	2.5780	5	4	2.51	5	10	2.68
6	3	2.4639	6	6	2.41	6	3	2.56
7	5	2.3571	7	6	2.32	7	8	2.45
8	5	2.2624	8	5	2.16	8	5	2.355
9	6	2.1077	9	1	(2.12)	9	5	2.19
10	1	2.0432	10	7	1.918	10	3	(2.16)
11	7	1.8753	11	3	1.81	11	6	1.948
12	2	1.8289	12	5	(1.745)	12	4	1.89
13	1	1.7624	13	6	1.71	13	3	(1.835)
14	1	1.6977	14	8	1.642	14	4	(1.771)
15	4	1.6685	15	9	1.685	15	3	1.735
16	8	1.6036	16	5	1.48	16	7	1.666
17	1	1.5730	17	3	(1.458)	17	10	1.607
18	9	1.5459	18	3	(1.428)	18	5	1.502
19	3	(1.4465)	19	5	1.325	19	3	(1.483)
20	2	1.4262	20	8	1.292	20	2	(1.45)
21	1	1.3847	21	2	1.28	21	1	1.417

Number	B003	Spessartite	Number	B004	Grossularite	Number	B001	Andradite
No	I	$\frac{d\alpha}{n}$	No	I	$\frac{d\alpha}{n}$	No	I	$\frac{d\alpha}{n}$
22	1	1.3448	22	6	1.264	22	6	1.348
23	5	1.2950	23	2	1.25	23	6	1.312
24	7	1.2637	24	2	(1.213)	24	5	1.284
25	2	1.2499	25	3	1.199	25	1	1.27
26	6	1.2343	26	2	1.164	26	2	1.23
27	2	1.2213	27	8	1.103	27	3	1.216
28	4	1.1706	28	0.5	1.101	28	2	(1.173)
29	2	1.1467	29	6	1.084	29	5	1.118
30	2	1.1367	30	1	1.076	30	0.5	1.11
31	1	1.1050	31	2	(1.061)	31	7	1.101
32	7	1.0756 α_2	32	5	1.05	32	1	1.092
33	4	1.0756 α_1	33	3	1.048	33	6	1.066
34	6	1.0575 α_2	34	5	0.99	34	4	1.006
35	4	1.0575 α_1	35	3	0.988	35	1	1.004
36	1	1.0495	36			36	5	0.992 α_2
37	1	1.0357	37			37	2	0.99 α_2
38	6	1.0243 α_2	38			38	10	0.9788 α_2
39	4	1.0242 α_1	39			39	6	0.971 α_1

3. Chemical Properties and Elements

The chemical properties of garnet is stable and not dissolved in HCL and HNO_3, but HF solution. Chemical elements, on the basis of chemical analysis to spessartite, grossularite and andradite occurred in Xinjiang, the result and end members are listed in chart 7. According to the end members from chart 7, they are mainly distinguished by spessartite, grossularite andradite but very less of the other members.

Chart 7 The chemical analysis and end member analysis of garnets

Item	Oxide	Number			
		B003	B004	B005	B001
Analysis Value (%)	SiO_2	35.74	39.43	38.85	35.05
	TiO_2	0.13	0.08	0.27	0.16
	Al_2O_3	15.83	21.98	20.10	0.81
	Fe_2O_3	2.43	0.89	3.45	26.70
	FeO	0.71	0.5	0.95	4.92
	MnO	40.87	0.1	0.1	0.02
	MgO	0.10	0.56	0.45	0.00
	CaO	0.32	35.19	35.13	32.60

	K_2O	0	0.10	0.1	0.00
	Na_2O	0	0.82	0.82	0.00
	P_2O_5		0.05	0.03	0.19
	Ing. loss		0.16		0.61
	Total	96.13	99.86	100.25	101.06
End members	Almonide	6.97	2.3	7.0	
	pyrope	0.5	2.1	2.0	
	Spessartite	73.2			
	Crossularite		67.5	57	
	Andradite				67.1

III. Technological Processing Requirements

The technological demand of garnet depends mainly on the transparency of the mineral. On the whole, if the mineral has no skeins, no impurities, any form of it can become a gem, but the best are those with bright colours. The minimum demand on the size is to be able to be carved into a plain crown facet and the diameter not less than 8mm. Those that are green in colour can be 5 mm in diameter.

Gems having the texture of garnet have a lot of technological name and different kinds of garnets have different technological names.

According to information, the mineral name and technological name of garnets are listed in chart 8 as reference.

Chart 8 The chart on the contrast of garnet's mineral name and technological name

Mineral name	Technological name	Remark
Pyrope	Red garnet	Red
Almondine	Rhodolite garnet	Dark red
Spessartite	Spessartite	Orange or brown
Grossularite	California stone, Altai emerald, Pakistan emerald	Green
	Cinnamon stone	Colour of Chinese cassia tree
	Tsavorite	Contain venadium, green

Andradite	Demantoid	Green , rich and bright
	Topazolite	Yellowish green
	Tsavorite	Black
Uvarovite		Fresh green

IV. Classification of Garnets

1. Spessartite

Usually in form of block, and those that are used as a gem are rarely in complete forms of crystal. The colours are those that have red as the fundamental colour, like brownish red, pink, dark red and rosy red, etc. The best is flaming red. They are from transparency to translucent, have the lustre of vitreous, and their specific gravity is 4.1852 – 4.2714 (the specific gravity of pure spessartite is 4.16 – 4.19). The refractive index is 1.82 (the refractive index of pure spessartite is 1.80). The elements of spessartite constitute 73%, almondine 6.97%. The diameter is usually 1-1.5cm, the largest as much as 1 kilo. It is mainly produced in granite pegmatite, in primary zone and metasomatic zone. This kind of garnet is carved into different kinds of crown facets and heart shapes and are very popular products. For the original crystal and its handicraft, see colour illustration 14. The colour index of spessartite: V=12.9551, X=0.5584, Y=0.3961, λ=593, Pe=0.8694.

2. Grossularite

The grossularite that is used as gems in Xinjiang can be divided into 2 types.

(i) Altai Emerald (Grossularite)

Commonly seen are block aggregate and isometric granular, it is rare to have complete crystals, some side of crystal is well developed. The colour is light green – emerald green, its colour index: V=85.9607, X=0.3369, Y=0.3422, λ=568, Pe=0.0395. The colour is bright, transparent – translucent. Its lustre is resinous and vitreous, its specific gravity: 3.5958 – 3.5922 (torsion balance) (The specific gravity of grossularites that comes from Pakistan and is clear green in colour is 3.63), refractive index 1.734 (the refractive index of grossularites that come from Pakistan and is clear in colour is 1.738). The elements of grossularites consitute 67.5%, the diameter of single crystal is 0.5 – 5cm. The size of the aggregate is 2-15cm and is produced in metasomatic aggregate of skarns. This kind of petal crown facet carved in garnet is bright in colour and crystal clear. It is dazzling and very popular. The original stone and its handicraft is in colour illustration 16,17.

(ii) Cinnamon Stone (Grossularite)

Mostly synneusis aggregate, isometric granule can be commonly seen. Its colour is brownish yellow – brownish red (colour photograph 18), its colour index: V=79.4476, X=0.3444, Y=0.389, $\lambda\alpha$=562,

Pe=0.2587. It has the lustre of resinous-vitreous, and is transparent – translucent. Those that have a good transparency and little cracks can be used as a gem. Its specific gravity is 3.5913 (torsion balance). The specific gravity of a standard cinnamon stone is 3.65, refractive index 1.734. The refractive index of a standard cinnamon stone is 1.743, with a diameter 0.5 – 5cm, some reach 8cm. It intergrows closely with Altai emerald, and appears to have a gradual changing interim relation. The colour of the carved products is not as good quality as Altai emerald. Besides, spessartite is also contained in the regional biotite plagioclase gneiss and schist looks brownish red, good crystal form, transparent, can be used as gem.

3. Andradite

The crytsal shape is round , and is a isometric granule. It is like a pressed dodecahedron and synneusis aggregate. The colour are emerald green, green, the yellow that has the fundamental colour of green and their interior colour. They are transparent – translucent, but mainly transparent. The vitreous lustre is strong and has cracks. Its specific gravity is 3.77-3.82 (torsion balance). (The specific gravity of a typical andradite is 3.85), refractive index: 1.88 (the refractive index of a typical andradite is 1.89). Its elements of andradite constitutes 67.1%, its diameter is usually 1-3cm, and is produced in the vein of asbestus among ultrabasic rock and associated with asbestus.

V. Geological Features of Garnet's Origin

There are different geological features for garnet's origin and are listed as follow.

1. Spessartite

The geological situation of garnets' origins is not the same, and may have the following four situations:

(i) Spessartite Produced in Contact Metamorphic Zone

The spessartite that is produced in contact metamorphic zone is mainly distributed in the contact zone of country rock (schist) and granite pegmatite, especially the inner contact zone. The garnet is brown red in colour, with a good shape of crystal and a diameter from 0.3-1cm. The distribution is not even and very often intergrows with biotite and black tourmalines.

(ii) Formation of Spessartite due to Magma Crystallization

It is very often distributed in the small crystals and granular structure belt of granite pegmatite. Spessartite is brownish red in colour, and appears in dodecahedron and isometric granules. The diameter is 0.2-0.5cm. and is distributed like stars. It intergrows with oligoclase and quartz. This kind of garnet can rarely be gems.

(iii) Formation of Spessartite due to Hydatogenesis

It is produced in the medium-large granular structure belt and block structure belt of granite pegmatite's mineral veins. Garnets in the small block structure belt constitute the pseudo-graphic texture with quartz, and are generally brownish red and reddish brown in colour. They are in isometric granule, block and sometimes, in rhombo-dodecahedron. The diameter of the granule is 0.3-4cm, and usually intergrows with oligoclase, microcline quartz and muscovite.

(iv) Spessartite Formed by Metasomation Having Again Four Types of Geological Situation of Origin:

(a) The aggregates in chain or belt shape are distributed in the medium – large granular structure belt and block structure belt of granite pegmatite;
(b) stored in the aggregate of quartz and muscovite;
(c) appear with the albite – muscovite metasomatic aggregate.
(d) appear as the asterisk distributing in albite that is in sugar granular.

This kind of spessartite is brownish red in colour is usually in block, isometric granules or rombus in dodecahedron. The diameter is generally 0.2-2cm. This kind of garnet always have crystals of gem level.

2. Grossularite

Grossularite as a gem (Altai emerald) and cinnamon stone belongs to the type of contact metaxomatic skarns. This skarns is occurred in the subsyncline of the composite anticline. The rock body is occurred in the thin marble among the biotite plagioclase gneiss in the middle Devonian system. The occurrence is in dip 40° – 70°, dip angle 50° – 60°. The marble is in lens shape,the length to width is 4:1.It mostly becomes metasomatic skarns body. Its minerals include epidote, garnets, calcite, albites, quartz and epidote. Garnets appear in bag shape, a small piece and the shape of lens, and is found in the middle part of skarns body distributed parallelly along the country rock intermittently. Altai emerald for gem use is in granullar shape with regular system and block of aggregate. The single crystal has a diameter of 0.5-5cm, the size of the aggregate is 2-15cm, and is produced in the middle part of garnet's mineral pocket, and appears to have transitional intergrowth with cinnamon stone. However, Altai emeralds are just produced in mineral pockets and mineral nests of large size. The smaller ones do not produce that kind of gem.

3. Andradite

Andradites of smaller size and bright colour are, at present just produced in the vein of asbestos among the stubachite in which two groups of cracks are developed. One group of cracks is in the strike of SN, the other EW. The SN group is the most developed. The length of 1½ width is 1:0.01 or 1:0.04 often distributed parallelly in belt. Andradite is produced in the asbestos vein of the crack appears in three forms:

(i) Andradite of oval-shape aggregate is closely wrapped by asbestos. The size of the aggregate is from a grain to a duck's egg. The monocrystal is usually 1-5mm, the granule appears in poikilitic, with tiny asbestos veins inside. Part of them appear in mono form. It has a good transparency with a diameter more than 3mm.

(ii) The Kaolin piece which is included by the asbestos is about several cm in diameter. It contains of andradite of a high transparency and crystals which diameter is more than 3mm.

(iii) The monocrystal of andradite in vertical asbestos has crystals in more complete shape and a good asbestos has crystals in more complete shape and a good transparency. Those with diameter more than 3mm is more commonly seen. In the augite-peridotite where the rock is strongly metamorphic or the vein of asbestos is developed where the crystal granules of gem level is relatively well developed.

VI. Utilization Value of Exploitation

Finding Xinjiang's garnets in granite pegmatite and metamorphic rocks has a bright future, mainly because the utilization value of spessartite, grossularite, Altai emerald and cinnamon is comparatively high, and some of them reach gem of medium grade.

Section Four Ruby and Sapphire

I. General Account

Ruby and sapphire are the beautiful-looking ones among the mineral of corundum. The distribution of corundum is rare in nature and those that can become gems are even rarer.

The history of using bright colour corundums with a good transparency as gems is of long standing, and corundum is among the five most previous kinds of gems in the world.

The utilization history of ruby and sapphire in our country was remote. In the Dynasty of Qing, ruby was used as the symbol on the crown for Princes and first grade officials, and sapphire was for third grade officials. Among the sacrificial objects of the Empress Dowager, there was a string of ruby court beads 60 pieces of ruby apricots, 40 pieces of ruby dates and 27 statues of Buddha. Besides, there were not less than 3790 pieces of various rubies and sapphires, among them 18 were the largest and weighed 68 Karat each. Those that weighed about 17 Karat were numerous.

A lot of countries consider sapphire as the symbol of kindness, honesty, cautiousness, noble character and high prestige. It is listed as the birthstone of July.

II. Physical and Chemical Properties

1. Physical Properties

Ruby and sapphire belong to trigonal system crystal pyramid, appear in barrel shape, column shape or plank shape when crystallizing. Transverse sleaks are commonly found on the surfaces. The diameter of the crystal is from less than 1mm to several mm. The large ones can reach more than 10mm. The length varies, on the whole it is from 1 to 10mm.

The mineral has the lustre of glass or diamond.

Greyish blue, greyish yellow are the common colours. As gems, they are usually white, red, blue, golden yellow and black in colour. There are also colourless, greyish green, violet blue, purple, orange, blueish green, brown and the colour of China pink. The most precious are red and blue.

There is not cleavage in corundum, but it is common to find that it cracks along the surface and underneath.

Corundum's hardness is 9. It is thought that the hardness of ruby and sapphire is larger than common corundum, and sapphire is again harder than ruby. It has a brittle nature, as a result, the material of the gem cannot be dashed on.

The specific gravity of corundum is 3.9-4.1. The actual specific gravity measurement of Xinjiang's ruby and sapphire is 3.977. According to information, the specific gravity of corundum which is for gem purpose (precious corundum) is larger than common corundum. For ruby, it is between 4.28-3.98, and for sapphire, between 4.16-3.90. According to De-Burnon measurement, the average specific gravity of 16 sapphire samples is 4.016, and that of 20 ruby samples is 3.977.

The melting point of corundum is as high as 2050°C.

The X-ray analysis in powder method result of ruby's powder crystal of a certain region in Xinjiang is in Chart 9.

Chart 9. The X-ray analysis result of ruby's powder crystal

No.	I	$\frac{d\alpha}{n}$	No.	I	$\frac{d\alpha}{n}$
1	2	(3.82)	15	8	1.374
2	5	3.47	16	4	1.238
3	3	(2.81)	17	3	1.19
4	9	2.55	18	3	1.148
5	7	2.38	19	3	1.125
6	5	(2.29)	20	4	1.099
7	10	2.086	21	4	1.078
8	3	(1.915)	22	5	1.044
9	4	(1.766)	23	2	1.042
10	6	1.735	24	0.5	1.019
11	10	1.601	25	5	0.998
12	2	1.548	26	3	0.996
13	4	1.514	27	2	0.985
14	7	1.404	28	1	0.982

2. Optics Properties

The thin slices of ruby and sapphire are transparent under a microscope. Uniaxial crystals (–) negative. Ne//C sometimes appears in abnormal biaxial crystals. The refractive indices are No=1.7670-1.7695, Ne=1.7594-1.7613. No-Ne =0.0082 Bright colour has a weak nature of polychrome, Ne=green, blue or colourless, No=blue.

3. Chemical Properties

The chemical nature of corundum is stable and not dissolvable in acid and alkaline. The main chemical analysis result of a certain region in Xinjiang is: Al_2O_3, 95.6%, Fe_2O_3, 0.62%; TiO_2, 0.55%; SiO_2, 0.62%. It is common to have a trace of mixture like iron, titanium and chromium.

The good quality corundum, that is those with bright colour and crystal clear transparency, can be used as gems. However, most of the corundums cannot satisfy the demand of a gem. These corundums are widely used in industry, mainly as abrasive, besides, as the bearing of clocks and watches.

III. Technological Processing Requirements of Ruby and Sapphire

Ruby and sapphire are generally treated as gems of great treasure. They are mainly red and blue in colour. Besides, those that are yellowish green and pink are very precious, too. If used to carve high quality jewels, they can be divided in two grades.

Grade 1: Pigeon blood or scarlet red, sky blue, transparent, no cracks, no impurities, larger than one karat.

Grade 2: Colourless, yellowish green and pink, transparent, no cracks, no impurities, larger than one karat.

Demands on ruby and sapphire of some processing departments:

Colour – rose, scarlet, purple red, pink and blue are the best. The other colours are yellow, green and orange, etc. Those that are large in size and a good transparency can do as well.

Texture of the crystal and the size – the interior of the crystal is transparent, but those with filiform and translucent can do as well. The crystal is small: for ruby, not less than 3mm, sapphire not less than 4mm, and there should be no serious skeins or impurities (except filiform).

The common products of ruby and sapphire are in the state of a "facet" and "polished" (or "plain") stone. "Facet" is generally carved in smooth surface in regular geometric state similar to diamond crown facet. "Polished" means those that are carved in shapes of oval, circle or pillow. The crystals that have a good crystallization is usually transparent to translucent. When carved in a polished crown facet, so long as the method of carving is correct, it can have dazzling asterim despite the colour.

IV. Classification and Characteristics of Ruby and Sapphire

The corundum that can be called a gem has many colours, but the main ones are red, blue, golden yellow, white and black, and they are considered to be the five treasures of the gem of corundum. The best is that has asterism. As a gem, the first demand on corundum is that the colour must be ideal, and

is completely transparent with no flaws and very few floss. The texture must be delicate and it should not be thin. If it can satisfy all these ideal conditions and have a good asterism, the quality will be the best.

Among the corundums found in certain regions in Xinjiang, rubies and sapphires are found.

1. Ruby

Rubies are usually rosy, rosy-pink, flamet-red and scarlet red in colour. The best colour of ruby which is blood red being called pigeon blood is a rare treasure in the world. The colour of the ruby produced in Xinjiang, in general, is lighter. Those commonly seen are light red and rosy red in colour (see colour **Photograph** 19).Rubies in other colours are less common. According to technological demand, as long as the ruby is not of dark red, the reder the better. It is believed that the red of ruby is because it consists of Cr^{+3} ion and it absorbs other colours and becomes red. On the whole, it is rare to obtain large size rubies. According to information, the largest pigeon-blood one in the world weighs 55 karats only, and those that are more than one to two karats are rare.

2. Sapphire

For sapphires of fine quality, colour is the key point. It must be sky blue in colour, like a big clear open sky that the sun shines again after the rain, or "indigo, deep blue". In certain regions of Xinjiang, the sapphires produced are lighter in colour, mainly light blue. It is generally believed that the blue in sapphire is because of the transition of Fe^{+2} and Ti^{+4}'s ions. Sapphire also has the difference between smooth and facet. When all the conditions are the same, facet is better than smooth. In nature, sapphire has more production than ruby, the size is large, too. According to information, a fine sapphire crystal more than 951 karats was found in Burma in 1929. In the present international market, sapphires of more than 5 karats are considered to be very precious. However, on the whole, sapphire is not as precious as ruby.

V. Appraisal Features of Ruby and Sapphire

1. The Difference between a Real Gem and a Fake

Synthetic ruby and sapphire are common fakes. The so-called "diamond" in clock and watch industry is synthetic ruby. Because ruby and sapphire are precious, imitations of various kinds emerge as the times require. On the whole, gem technologists and appraisers distinguish the real ones from fakes according to the following factors:

(i) The crystals of natural corundum usually have "cotton" characteristic of straight line in some degree; synthetic ones do not have it, but sometimes they have cracks from outside to inside, or arc concentric stria.

(ii) The colour of natural gem is "pure", even if the asterism cannot be seen, one can see the brilliant lustre. The colour of the synthetics is superficial and too well-distributed to have brilliant lustre.

(iii) The hardness of natural corundum is 9, and it does not have "cattle-hair stripes", but the synthetic ones cannot reach such a hardness.

Besides, sometimes synthetic have small oval shape or circular air cells which are regularly distributed.

According to the above three factors, we can more or less distinguish real ruby and sapphire from the fakes.

2. The Difference Between Ruby and Ruby spinel (Spinel Ruby)

(i) The colour of ruby is brighter and has the feeling of a pink tint or a purple tint in red; the colour of ruby spinel is rich,usually rubellite real red dark red and pink, etc.

(ii) Skeins are common for ruby spinel, far less for ruby.

(iii) Ruby has "star light", but ruby spinel does not have "star light" because mineral is anisotropic. The optical property of ruby spinel is isotropic body. Ruby is harder than ruby spinel, but the latter one is much brittle.

3. Sapphire and Synthetic Glass

Synthetic glass is a kind of blue glass or blue burning material. It is also made into handicraft.

(i) Colour – the colour of synthetic glass is bright and clear, but not pure, and can be easily distinguished from sapphire.

(ii) The colour form – synthetic glass does not have any form of colour, but even sapphire, as well as ruby has concentric hexagonal form, can be carved into a form of colour " Λ " or "–". This effects of light is much more obvious in water and particularly in diiodomethane.

(iii) Synthetic glass has a low specific gravity. When compared with sapphire, it is very light in feeling.

(iv) The products of sapphire, because of its high degree of hardness, do not have any cattle – hair stripes; the hardness of synthetic glass is 5.5, and always leaves the mark of cattle-hair stripes.

(v) There is often a sand inclusion, "cotton" characteristic, brilliant lustre in sapphire but not in synthetic glass. Only air cells often occur in the glass.

VI. Geological Feature of Ruby and Sapphire

It is commonly believed that corundum is formed under the condition of rich Al_2O_3, but lacking of ionizing SiO, so that corundum and its gem is mainly related to those of that alkolie (and basic) magma, such as syenite and nepheline-syenite, urtite, theralite, etc. But it is true ruby and sapphire occurs in granite pegmatite, eg. sapphire ore deposits of Mogu ore region, Kaitai of Burma is just produced in the granite pegmatite. Furthermore, in regional metamorphic process, rich Al_2O_3 contains rocks, corundum and gem may be formed in metamorphism. Therefore the most famous ruby ore deposit in the world is occurred in the gneiss and marble of Archaean group. The primary deposit of the Mogu ore region, Kaitai of Burma mainly belongs to this type. The corundum and its gem in Xinjiang also belong to this type. It is just the biotite plagioclase-gneiss of which contains corundum (colour photograph 20).

Section Five Precious Spodumene

I. General Account

Spondumene is the main mineral of the rare element lithium. Its chemical element fourmula is Li Al Si_2 O_6. The colour is bright and crystal clear. Those with strong lustre of silk can be used as a gem. In Xinjiang, only those that are light green and yellowish green in colour can reach the gem level. In order to differ from the mineral name, it is named precious spondumene. It is named light green gem in some information, but since it is easy to be confused with beryl, the name is not adopted.

II. Physical and Chemical Properties

1. Physical Properties

Precious spondumene belongs to clinorhombic system, clinocolumn group. It is symmetry type of L^2PC.

The crystal is usually in plank shape, column shape and plank column shape, in block and needle are rare. There is riband parallelly along the crystal edge on the plane often has {100} twin. The size of the crystal have a great difference. They are usually 0.3-1cm long, 0.1-5cm wide, 0.03-0.3cm wide. The widest is 22cm long, its ratio of length, width and thikness is 25:10:1. The colour is mainly white, rose and light purple, besides, there are also yellowish green (colour illustration 2.22), light green, colourless and grey. Emerald green is rare.

Precious spondumene has the lustre of glass and silk {110}, complete cleavage and uneven fracture. Its hardness is 7.2-7.4 (actual measurement), specific gravity: green 3.172-3.183 (actual measurement). They are mainly translucent, those that are completely transparent are rare.

The emerald green spondumene produced in the state of North Carolina, America is rare to have more than 2 karats.

2. Chemical Properties and Chemical Elements

Precious spondumen is dissolvable in the solution of hydrochloric acid, sulphuric acid, nitric acid and sodium hydroxide.

The colour of precious spondumene mineral changes into white after being heated.

The chemical analysis result of light green spondumen is (%):

Li_2O 7.46, 7.41, K_2O 0.025 · 0.01, Rb^2O < 0.002 · 0.002, Na_2O 0.16 · 0.15, CaO 0.12 · 0.12, MgO 0.25 · 0.125, MnO 0.14 · 0.17, Fe_2O_3 2.13 · 2.56, Al_2O_3 24.00 · 24.38, SiO_2 65.18 · 64.18, Nb_2O_5 0.099 · 0.0024, Ta_2O_5 0.0013 0.0011, total 99.57, 99.11.

3. Optical Properties

Light green spondumene is about (+) 2V=60°, Ng=1.6737, Nm=1.6712, Np=1.6650, Ng∧C= 19°– 24°. The thin slices are colourless, and have a weak nature of polychrome, dispersion of colour r> υ

The powder method of the X-ray analysis is: 4.19(8), 3.20(7), 2.92(10), 2.77(10), 2.45(8), 2.11(5), 2.05(6), 1.925(6), 1.860(9), 1.565(9), 1.462(8), 1.215(8), 1.173(8).

The characteristics of precious spondumene's infrared spectrum (see figure 4).

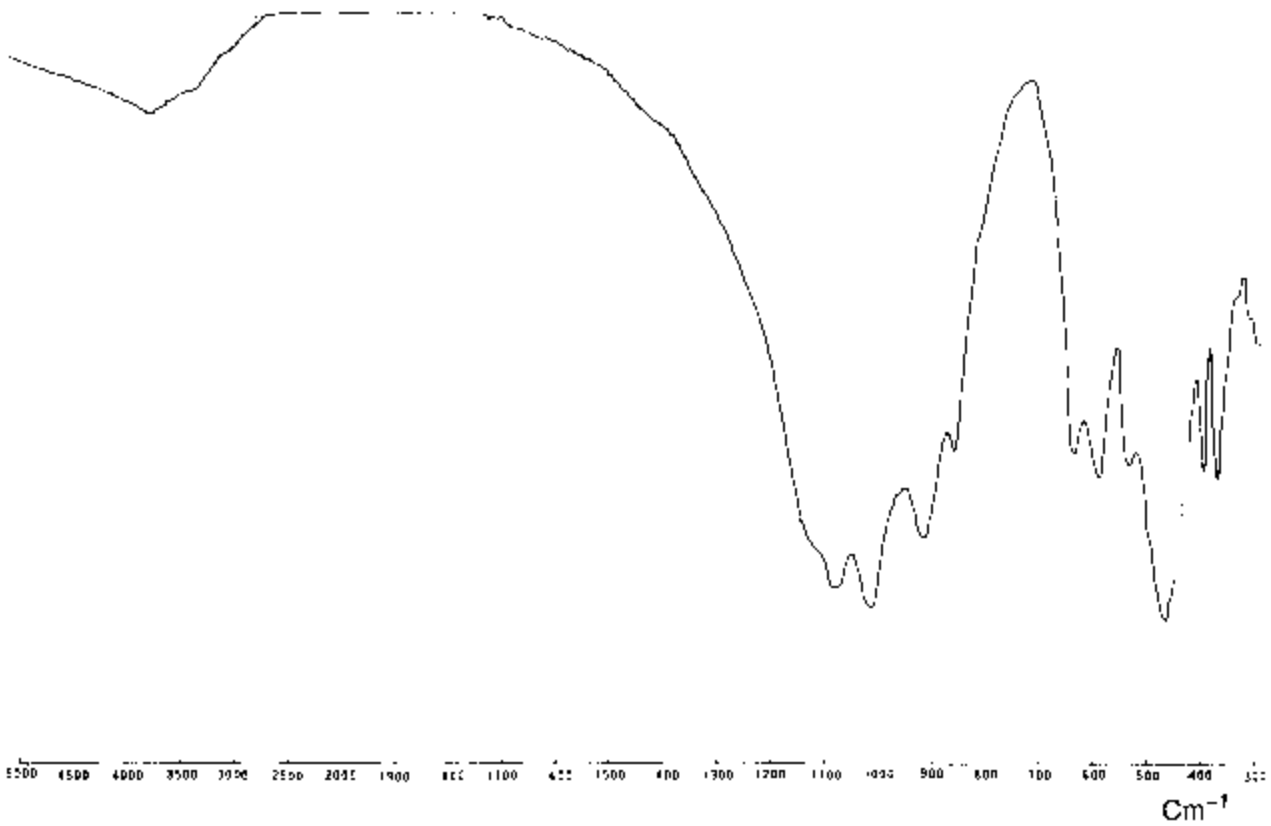


Figure 4 The characteristics of precious spondumene's infrared spectrum.

III. Technological Processing Requirements

At present, there is no specific technological demand on precious spondumene as a gem. On the whole, the first condition for precious spondumene is to have a good transparency, bright colour and the crystal has little cleavage of cracks. Then, it can be carved and processed. The size must at least be able to be carved in a crown facet. Precious spondumenes that can be used as a gem have colours like light yellow, light green, light purple, jade green, yellowish green lilac and so on. Of all the colours the jade green one is the best.

IV. Appraisal Features of Precious Spondumene

The spondumene is mainly distinguished by its column-slate crystal shape, silky lustre and a group of {110} cleavage. Precious spondumene is easily oxidized, as a result, there is always a layer of white powder on the surface, if it is in moisture. When burned in fire, spondumene can redden the flamme (lithium). If we put its powder on an iron plate and heat it in darkness, the flamme will first be in sky blue and then flaming red.

V. Geological Features of Precious Spondumene

The precious spondumene in Xinjiang that can be used as a gem can just be seen in the rare metal soidum – lithium type of granite pegmatite. This kind of granite pegmatite has a more complicated inter growth fabric of minerals, such as spondumene, lithium mica, phosphorous lithium manganese, phosphorous lithium aluminium, muscovite, colourful tourmaline, beryl, nibium tantalum iron ore, phosphorous calcium thorium and thorium hafnium zircon, etc.

The spondumene in that kind of granite pegmatite is usually crystallised originally there. The crystaline is more complete, and is more concentrated in the foliated albite – spondumene zone and the quartz – spondumene zone . Vein of granite pegmatite which is not good in differentiation, spondumene is concentrated in the interior of the veins, usually in the expansion position of small piece pegmatite zone; a small amount is produced in small – medium granules of pegmatite zone, that is near the position of the vein wall. The common feature of spondumene in these two zones is: the block and euhedral degree of the spondumene and the rock forming mineral. That is microcline, perthite and quartz is unanimous. That means they were produced and crystallized at the same period in the cleave landite – spondumene zone the foliation is vertical to the spondumene and it is surrounded by the cleave landite.

In the regions of Xinjiang where sodium – lithium granite pegmatite is distributed, it is possible to find new places of production for precious spondumene.

Section Six Purple Apatite

I. General Account

Apatite is one of the accessory mineral that is most widely distributed in different kinds of rocks. Its chemical elements formula is $Ca_5[PO_4]_3(F.\ OH.Cl)_3$. When the crystaline is sparkling and transparent, with a lustrous colour and less cleavage, it can be treated as a gem. Its gem name and mineral name are the same. Up till now in Xinjiang, the apatite that can be treated as a gem is blueish-purple in colour, andd so is called purple apatite. (colour photograph 23,24)

II. Physical and Chemical Properties

1. Physical Properties

Purple apatite belongs to hexagonal crystal hexagonal bipyramid group. It's symmetry type of L^6PC.

Crystalines are usually in column shape, short column or granular shape. Usually it is 1-3cm long, with a diameter 0.5-1.0cm. The heaviest of those that are gems weight 45 karat.

There are a great variety of colours, we can say they are multicolour. Principally they are colourless, grey, brown, black, light green – green, yellowish – green, blueish grey and blueish – purple. Those that are blueish purple in colour have clear vertical veins on the facets, irregular at the cut, transparent to translucent, hardness 5, specific gravity 3.13-3.24.

2. Chemical Properties and Chemical Elements

The chemical nature of purple apatite is not very stable, and it can be dissolved in hydrochloric sulfuric nitric, hydrogen Fluorine, phosphoric acid and inorganic acid.

The analysis result of main chemical elements is (%): P_2O_5 38.98, CaO 52.65, Fe_2O_3 0.48, MnO 0.17, $[Ce]_2O_3$ 0.124, $[Y]_2O_3$ 0.513, F 2.38.

3. Optical Properties

The thin pieces of purple apatite are colourless under a microscope, Uniaxial crystal (–) negative No=1.645 – 1.631, Ne=1.643 – 1.629, No–Ne= 0.002.

The main strong rays of X-ray analysis of crystal powder are: 3.46(7), 2.80(10), 2.71(8), 2.62(5), 2.25(6), 1.935(6), 1.835(7), 1.713(5).

According to its chemical elements are the X-ray analysis result of crystal powder, its mineral belongs to fluoride apatite.

III. Technological Processing Requirement

There is no specific rule of technological demand for purple apatite as a gem. According to the present utilization situation, its main demands are: bright colours, crystal-clear and transparent, no cleavage of veins and has a certain size (able to be carved in a plain crown facet is the minimum).

Because the hardness of purple apatite is relatively lower than ordinary gems and with a brittle nature, gems of little cleavage must be used for carving and polishing.

As a gem, the colours of purple apatite that are most welcome are blue, greenish blue, blueish purple, green, those that have the lustre of a cat's eye are more precious.

IV. Appraisal Features of Purple Apatite

Purple Apatite, a hexahedral column-shaped crystal, has two groups of more developed cleavages that are different from other minerals. The powder of purple apatite can be dissolved in nitrate acid, adding a little bit of ammonium molybdate, some lemon yellow phosphate ammonium molybdate sediments will be produced.

V. Geological Features of Purple Apatite's Origin

From the present situation, the purple apatite in Xinjiang that can be of gem use is produced in granite pegmatite, and this kind of rock usually has the value of rare metal deposits. Apatite is produced in different structure zones of granite pegmatite, and at the edge of the quartz nucleus. The purple apatite that is of gem use is closely related to the later period of granite pegmatite that has metasomatism. Its mineral intergrowth are garnets, tourmalines, phosphorous iron maganese deposits, albite, spondumene, bismuthite, lithionite and the later period of quartz and muscovite.

In certain regions of Xinjiang, apatite is distributed in granite pegmatite and can be chosen as gem material.

Section Seven Topaz

I. General Account

It is called topaz in mineralogy, its formula of chemical elements is Al_2 [Si O_4] $[F.OH]_2$. Topaz accords with the gems demand, when used as a gem, it is called topaz meaning a yellow crystal. Topaz is a gem widely looked upon. Many countries praise topaz as "the stone of friendship", symbolising true friendly sentiments, friendship and fraternal love, and is listed as the birthstone of November.

II. Physical and Chemical Properties

1. Physical Properties

Topaz belongs to rombic system, the group of rombic bipyramid, it is type of symmetry $3L^2$ 3PC.

The shape of the crystal is mainly irregular and granular-like. The surface of the column and cone can be seen with a complete crystal, but complete rombic column – like crystals are rare.

The colour range is large from colourless, white, blue, yellow to rosy red, etc.

{001} cleavage – complete, hardness 8, specific gravity 3.502 (actual measurement), the lustre of glass, transparent – translucent, conchoidal fracture.

2. Chemical Properties and Chemical Elements

The chemical properties of topaz is stable, it is generally not dissolvable in inorganic acid, but can be slightly dissolved when soaked in sulphate. Analysis of main chemical elements is: Si O_2 34.28%, Al_2O_3 53.34%.

3. Optical Properties

Thin pieces of topaz are colourless and transparent under a microscope. The polychrome nature of the light-coloured ones is not obvious, but it will be clear when the deep-coloured ones are cut in thick slices: Np – yellow; Ng – pink. Refractive indices Np=1.6117, Ng=1.6283, (+)2V=50° – 60°.

The main strong rays of X-ray analysis of crystal powder are: 3.70(10), 3.20(10), 2.93(10), 2.36(8), 2.10(10), 2.05(6), 1.86(7), 1.67(5), 1.525(5), 1.416(9), 1.352(9), 1.01(5), 0.992(9).

III. Technological Processing Requirements

Topaz is a medium – low grade gem, the utilization is more common. If used as a gem, the demands are mainly, a good transparency, bright colours and no clear cleavage. In Xinjiang, blue topaz is the most precious, second is honey yellow and rose, besides,red, China pink and deep orange. The chromatism size should not be smaller than 8mm.

IV. Appraisal Features of Topaz

Topaz is different from other minerals because of its high degree of hardness and {001} cleavage. After being treated by heat, the colour will have a great change and become even brighter. However, the newly formed coloured will be damaged by heat or strong sunlight. Topaz is easily confused with yellow sapphire and citrine. The difference between topaz and yellow sapphire is: very often yellow sapphire has lux and lustre; topaz does not have such a feature. Yellow sapphire can beat topaz in hardness, topaz has an obvious {001}cleavage, but yellow sapphire does not have any cleavage. Because the size of yellow sapphire is generally smaller, the choice is not so good in carving, and on the handicraft there is always a skein of silk floss. The size of citrine is bigger and has a better choice, and as a result, the carved product generally has no skein of silk floss. The difference between topaz and citrine is: the specific gravity of citrine is 2.6-2.7, that of topaz is about 3.5. Citrine is lighter, with a brittle nature and no cleavage. Topaz has obvious cleavage.

V. Geological Features of Topaz's Origin

At present, topaz that can be used as a gem in Xinjiang is produced in the crystal cave of crystal deposits in granite pegmatite. A piece of rather complete crystal mined in the crystal deposit of empty pocket shape in certain areas of Xinjiang is 18cm long and as transparent as water. It weighs 7.68 kilo (colour photograph 25). The mineral intergrowth of that deposit is quartz, feldspar apatite, fluorite and beryl.

Section Eight Amazonite

I. General Account

Pegmatites of different kinds have a wide distribution in Xinjiang, in these pegmatites there exist various kinds of minerals. Pegmatite related to Amazonite, so far as we know, is mainly distributed in the Altai District and Hami Prefecture. Pegmatite deposits with rare elements in Altai are famous all over the world. With the exploitation of the rare elements in the ore deposits, some gems and jade are obtained at the same time, Amazonite is one of them. The amazonite is beautiful in colour, with fine and smooth texture. Various jewelleries made of it are very popular in the market. However, it is just in recent years that Xinjiang begins to develop amazonite to make handicraft.

II. Physical and Chemical Properties

Amazonite is a variant of minerals, that is, a kind of microcline that contains rubidium (Rb) and cesium(Cs). It belongs to the Triclinic System. The formula of its chemical elements is; $KALSi_3O_8$. Its dioptre: Ng=1.525-1.530, Nm=1.522-1.526, Np=1.518-1.522, double refractive indices: Ng-Np=0.007-0.008, (-) 2V=77° – 84°.

Amazonites are always in lumps, their crystal appears in short columnar shape or paralled {010} thick planar form, and has two groups of cleavage that are vertical, along {001}, the cleavage is complete, but it is less complete along {010}.

The colour of Amazonite appears from light green to skyblue (colour illustration 16.26). It contains impurities like Rb_2O 0.06-1.4%, Cs_2O 0.2% and a small amount of lead (Pb). The colour differs from the content of rubidium(Rb) and cesium(Cs).

Its hardness is 6.5, the specific gravity is 2.54-2.57. It has the lustre of glass, in conchoidal and flat form, it is translucent and generally has cracks, which is associated with the development of the cleavage on the mineral itself.

Amazonite under polariscope is colourless, transparent and with negative protuberance and shows a planar and columnar shape; its interference colour is in first-grade, white-grey and lattice twin always with flaky muscovite, granular quartz and other minerals associated, their textures are in fine-crystal texture, pegmatite texture and clumpy structure.

THE INFRARED SPECTRUM OF AMAZONITE (Fig.5)

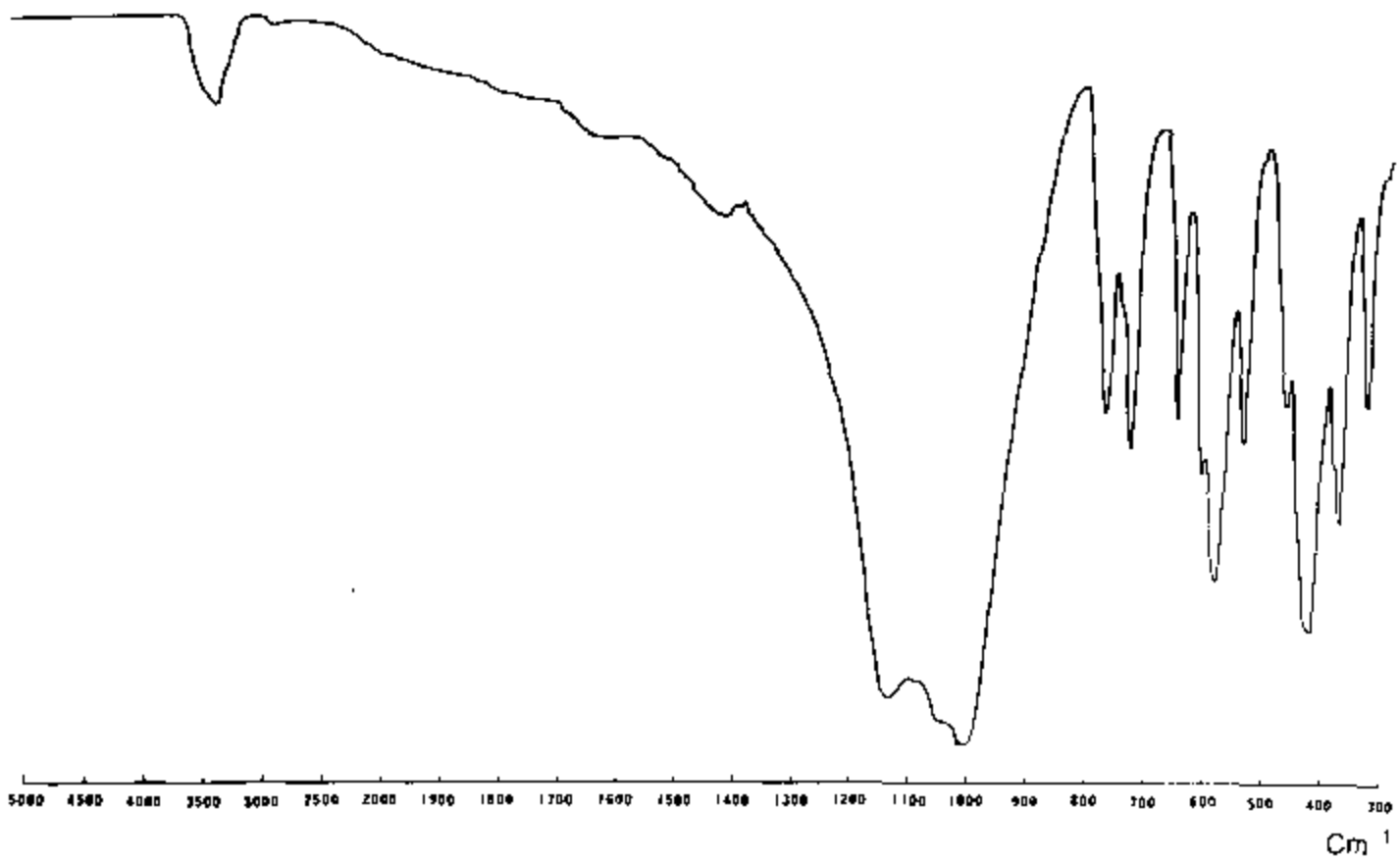


Fig. 5 The characteristics of Amazonite infrared spectrum

The selected analysis of amazonite shows that it also contains BeO 0.025%, Rb 0.28%, Cs 0.014%. in addition, the analysis under laser spectrum shows that it contains following trace elements: Cu 0.0005%, Pb 0.025-0.07%, Sn 0.001%, Cr<0.005%, Ga 0.004-0.006%.

The chemical properties of amazonite is not stable. The chemical analysis results of amazonite in granite pegmatite in some areas of Xinjiang can be seen in chart 10.

Chart 10 Chemical Analysis Results of Amazonite

Analysis item / Name of the mine	Analysis item%													Specimen No.
	SiO_2	TiO_2	Al_2O_3	FeO	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	ign. loss	total	
Mine A	64.915	0.0475	18.07	0.375	0.135	0.01	0.42	0.14	13.22	2.195	0.018	0.07	99.616	2
Mine B	65.08	0.01	18.49	0.35	0.11	0.006	0.09	0.20	11.66	3.26	0.010	0.14	99.406	1

III. Technological Processing Requirements

In processing, there is no standard regulations technologically for amazonite , yet,the request is on the whole, to make it bright and nice in colour . Pure green and skyblue are the best colours. The colour should be as rich as possible and must be even. The more transparent , the better, with few or no cracks. The smallest piece is 10×20×20m, those of higher quality should be larger than 50×30×30mm. As for those lower grades, if their uneven distribution of colour and iron-rusted phenomenon are no more than 20% of the surface area, they are useable as well.

IV. Geological Feature and Occurrence

The geological situation of amazonite in Hami, Xinjiang. is as follows: The mining areas topographically belong to the east section of the protruded middle part of the Tianshan Mountains. Stratigraphic distriction belongs to the Xin Xin Gorge Group of Sub-sinian Kingdom in Kavablak Group. Upper Palaeozoie Kingdom of The Carboniferous System and Permian System; and the third and fourth system of Cenozoic Group.

Magmatite and structure: in the mining areas, intrusive rock grows widely, intrusive rocks of Variscian movement are in the main. Intrusive rocks of different periods are all subjected to the restraint of their tectonic structures of fractures (rift structure). The intrusive rock of Caledonian movement: lithelogical character is in speckle-like signature and gneissoid granite. The intrusive rock of Variscian movement develops widely, especially the intrusive rock in the middle period of Variscian movement is most extensive and of a large scale, many periods and kinds, it is the main parent rock in forming skarn ore deposits and pegmatite ore deposits. The lithelogical characters are divided into Ultrabasic rock, diorite, gabbre-diorite, quartz-diorite, mica-granite of medium-sized and fine grain, muscovite granite and the like. Biotite granite and muscovite granite are associated with the formation of ore mines. As for vein rock, there are olivinfels vein, granite vein, gabbro vein, diabase vein, diorite vein, quartz porphyry vein, fine crystalline vein, pegmatite vein and quartz vein. The closely related vein to the formation of amazonite ore is pegmatite vein.

Tectonic structures are mainly in folds and faults. Amazonite is located in the middle section of the protruded central part of the Tianshan Mountains. Sub-fault activity of each period is intense and accompanied with the activity (movement) of magma. Mining areas are situated in the centre of the folded belt.

The intrusive rock associated with the formation of amazonite is medium-grained fine granite and biotite granite of two periods.

(1) Medium-grained-fine Granite:

The dissimilation of the rock matrix is obvious, country rock has a clear erosive action and mixed lithification, a great many of pegmatite veins develop in the rock matrix and surrounding rock, which usually form the amazonite ore body of industrial value. The granite in this period has light pink potassic granite and white-grey muscovite granite.

(i) Potassic granite is light pink in colour, medium or coarse grained, speckle-like in texture and clumpy in structure. Mineral composition: potassium-feldspar (30-40%) oligoclase (20-30%) quartz (30-50%), muscovite (1-5%), biotite (1-2%) and a small amount of fluorite, sphene and limonite.

(ii) Muscovite granite: white-grey in colour, medium-fine-grained, speckle-like in texture clumpy in structure and with a strong sodaclase mineralization. Mineral compositions: microcline (30-35%). Oligoclase or albite (25-35%), quartz (30-40%), muscovite (5-10%) and a small amount of apatite, garnet, zircon, sphene, epidote and limonite.

(2) Biotite Granite:

Rock matrix is 30 km long, 3-8 km wide, differentiated pegmatite vein in the eastern rock matrix contains amazonite, smoky crystal. The rock is in grey, yellowish brown and pink colour, coarse-grained in texture and clumpy in structure. Mineral compositions: microcline (35-40%), feldspar (10-25%), quartz (20-35%), biotite (3-5%) and a small amount of muscovite, zircon, sphene, apatite, garnet, magnetite and some other minerals.

Vein rock: granite pegmatite is in the main, the veins of granite fine crystalline rock and quartz are secondary to it. Various vein rocks file in along the cracks and the surface of the strata, which draw a clear line between country rocks. The main mineral is granite pegmatite is amasonite and then beryl and smoky quartz.

The size of the ore deposit and the features of the ore body are many rock veins in the mining areas which fall into three kinds:

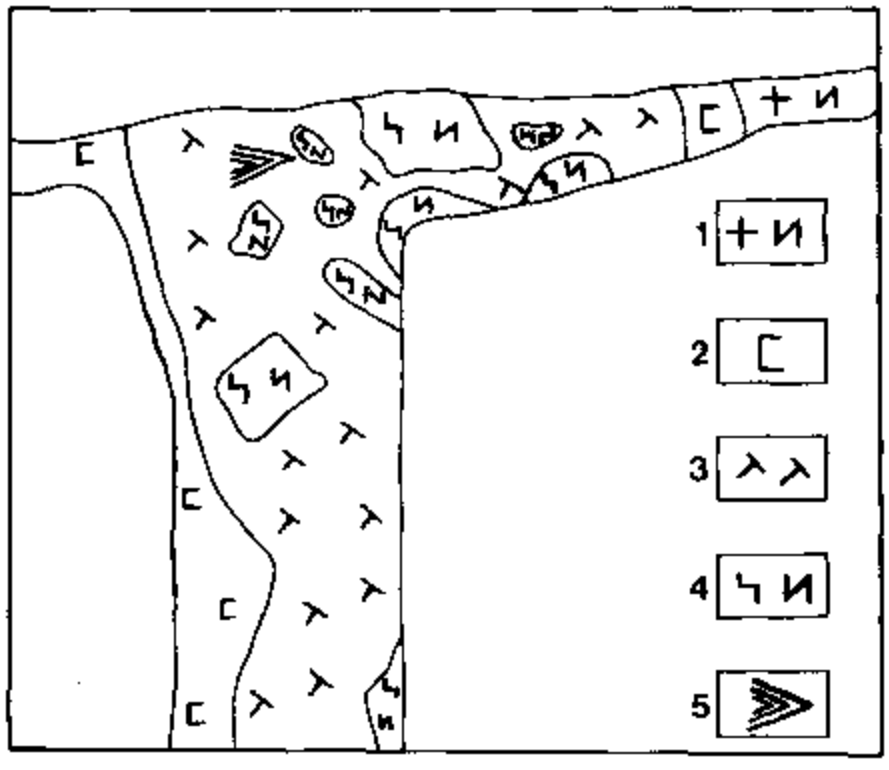
(a) Mineral vein: it is the granite pegmatite vein that amazonite content is higher than 5%, the diameter of the granulars is bigger than 2 cubic cm, the colour is bright and with few cracks. It has a fixed technological value.

(b) The mineralized vein: it is the granite pegmatite vein that contains amazonite less than 5%, the diameter of the granulars is smaller than 2 cubic cm and with uneven colour and coarse texture and clear cracks. It has little technological value.

(c) Common pegmatite vein: it is the vein containing no amazonite or other beneficial minerals.

In the mining areas, there are numerous mineral veins and mineralized veins of different sizes. Here, the features of one of the mineral veins is introduced: the mineral vein is located in the center of the river valley, it is dozens of miles long, several miles wide. The alignment is 40° tending to the north west. The lower wall lithological character is carbon-crystal graystone, the contact plane is 332° < 72° The hanging wall country rock is biotite granite, the contact plane is 315° <72°, the ore vein is obvious. Feldspar-amazonite-quartz-massive belt stands in the centre. Meta-graphic texture belt and fine-grained

structure zone are in the outer part. Amazonite yields in the massive belt. The feldspar-amazonite-quartz massive belt is mainly formed by perthite, Amazonite, quartz, and then muscovite and biotite etc. (See Fig. 6)



1. Granite
2. Meta-graphic structure belt
3. Massive structure belt
4. Amazonite
5. Mica aggregate

Fig. 6 Structure figure of Amazonite ore body

Massive quartz: grey-and-white in colour.Massive diameter is 10-40cm, account for 30% or so. Perthite: light yellowish in colour,planar in shape,massive diameter is 30-50cm, constituting about 40%.

Amazonite: light green and blueish green in colour, crystal is in planar form, it is usually 15×15×10cm in lump shape, the largest one is 10×50×50cm. Besides, biotite and muscovite, smoky quartz and lepidolite are formed in this belt.

Meta-graphic texture belt is distributed on the both sides of the massive belt, the quartz appears coarse, which is set in the feldspar crystal. Small crumby and striped muscovite and quartz-muscovite replacement aggregates are seen in this belt. Black tourmaline, beryl, smoky quartz and lepidolite etc are also found in this belt.

Mineralized vein of Amazonite is distributed in the middle part of the ore district, it is in the cracks and at the intersection of cracks of biotite granite that the Amazonite appears to be in lens shape and massive form. Its texture is mainly in quartz and feldspar massive form, while feldspar in yellow and grey colour, quartz in white (pale) grey colour. Amazonite, muscovite and smoky quartz and other minerals are seen in the mineralized vein.

Amazonite in the amazonite mining area in Hami is mainly characterized by: few cracks, beautiful colour, fine lustre, under-developed cleavage and large and small pieces.

(i) The large piece Amazonite: the diameter is more than 5cm in piece form. It is mainly produced in feldspar-quartz massive belt with pegmatite vein structure, usually intergrows with quartz and muscovite. The amazonite is in planar crystal form, the crystal is perfect,common size is 10×10×5.5cm,some

may reach 50×50×10cm and the surface of the crystal is 1 square metre and in light blue and blue green colours.

(ii) The small piece Amazonite is mainly produced in simple-structured pegmatite vein which is usually in complete mineralization. When it is produced in amazonite-quartz replacement aggregate, it is in short columnar shape and planar crystal form. It is as big as 1.5×1.2×0.5cm, some may be 3.5×2×2cm and in blue green and sky blue colours.

A brief account on amazonite production in Altai granite pegmatite dykes: tourmaline is at the edge of the granite rock, the rock is in cupola. Its area is about several square kilometres. The interior is in porphyritec texture and is the large granules of biotite granite. The exterior is small granules of dimicaceous and mica granite and has albitization, part of it produces beryls and amazonite. Besides, along the edge of the granite, there are small crystal rock veins similar to the constituents of mica granite, some small crystal rock veins take the transition to become small granules pegmatite veins in graphic texture, some of them are in cryptomerous texture at the sides: the centre is the pegmatite of that has cryptomerous deformation texture. Very often there is mineralization of amazonite in this dyke. Usually there are two kinds of mineralization. One is the amazonite which is mineralized in irregular veins or infiltration veins. Amazonite of gem grade can be found in this sort of dikes. It has a certain utiled value in technology. The other sort of amazonite is produced in granite aplitic dyke.

Its granule is small. It is a uniform distribution in irregular veins in the dyke. The big block or piece is rare. This sort of amazonite is not good enough to be utilized with in technology.

Section Nine Diamond

I. General Account

Diamond is named gem diamond or diamond. Cut as jewellery. Usually we call it diamond gem or gemdiamond. Those that are not cut called diamond.

Diamond is the most precious type of gem, and those that are of high quality are very expensive. Ever since ancient times diamonds, which had been found were treasured by people.

"Karat" is the weight unit of diamond. There is 0.2 gram in 1 karat. In the history of Xinjiang, there were records about the excarvation of diamond. In 1984, people from the area of Hotan in Xinjiang found crystal that was extraordinarily sparkling in the area of the Kunlun Mountains. After the examination of the relevant geological department, it was confirmed that the diamond was of a gem level. This weighed 1.012 karat and belonged to the second grade.

Diamond is a kind of pure and transparent gem, symbolising naivety and faultless, and is listed as the birthstone of April.

II. Physical and Chemical Properties.

1. Physical Properties

Diamond belongs to the system of crystal that are equal axis, the crystal usually has octahedron, dodecahedron, and are in cubes and combinated form. The special feature of the form of crystal is that

the edge lies in ore. The angle between two sides becomes nearly round. So that the crystal looks round and much abrasion in different kind of the surface of the diamond in colour, usually it is a transparent crystal either colourless or light yellow. There are also "special colours" like blue, pink, green, purple and gold, but they are rare. The specific gravity of Xinjiang's diamond is 3.5213. The lustre of diamond shown under x-ray will have a light blue phosphorescence and it has a brittle nature. The diamonds of Xinjiang sometimes have black graphite inclusion.

2. Chemical Elements and Chemical Properties

The chemical element of diamond is carbon. Its chemical nature is very stable, even under the function of strong acid and strong alkali, or heated to several hundreds of degree (less than 700°C), there will not be any reaction.

3. Optical Properties

Transparent, isotropic body, under the polarizing microscope dioptre rate 2.417 (yellow light).

III. Technological Processing Requirements

The factor of diamond's evaluation is mainly from the quality, shape, weight, colour and flaw.

(1) Quality and Shape

Diamonds used for diamond processing must be more regular in shape generally, as transparent as water and having a bright colour.

(2) Size and Weight

The larger the size of the diamond, the higher the price. Usually those that are 0.01–0.24 karat in weight are small diamonds, from 0.25–0.99 karat are medium ones and large diamonds are those more than one karat. Xinjiang has found large diamonds.

(3) Colour

The best are colourless but there are also other colours. Our country use numbers to grade the colour of diamond. For the best which is white in colour has 100 colours, and the following are divided into 99,98,97,.....85 according to the grading of colours. When it has 85 colours, an obvious yellow can be seen, and those that are below 75 colour grade, the higher is the price.

(4) Flaws

Flaws mean principally "dirts", "cracks" and "inclusion". "Dirts" mean the impurities of the gem during the process of crystalisation. They may appear in forms of spots, floss or specks. Flaw is expressed in "the degree of perfection". Under the observation of a ten fold microscope, it is divided into perfect grade flower(pure), micro-flower, flower 1, flower 2, flower 3 and big flower (see chart 11).

Chart 11 The grading of ornamental diamonds and quality standard (1978.10)*

Grades	Quality	Colour	Size	Remark
Special grade	Crystallied, completely transparent no flaw (floss of cracks coverings and dirts) ie. perfect (pure).	Colour of pure water, fire and water, pure red diamonds, pink diamonds, blue diamonds, black, golden, brown or colourless with yellowish tints have more than 96 colours.	The crystal gem can carve a large diamond more than 3 Karats (about 40% more than the product) Does not include those "global big treasures"	Refers to those diamonds that are superior in quality, colour and size.
Grade 1	ditto	ditto	Can only carve medium and large diamonds of about 1-3 Karats	Among the three standards one of them is inferior than the superior
	Crystallized, completely transparent, flaws limited to micro-flower, flower 1	ditto	Can carve large diamonds of about 1-3 Karats	
Grade 2	Crystallized completely transparent, flaws limited to flower 2	96-90 colours, can not be lower than 85 colours.	Can carve medium diamonds and large diamonds more than 1 Karat	On the whole the three standards have a certain distance from the superior one
Grade 3	Crystallized completely transparent, flaws limited to flower 2, flower 3.	90-76 colours	Can carve medium diamonds and large diamonds more than 1 Karat	Among the three standards one can not reach that of grade 2.
	The same as special grade	The same as special grade	Can only carve small diamonds 0.01-0.24 Karat)	The quality and colour are that of special grade but the size is too small.
Grade 4	The same as special grade	The same as special grade	Can only carve a single petal gem as a ornametal for the setting of diamonds (size within 0.01 karat, of about 300-400 a Karat)	

Grade 4	Crystallized completely transparent, flaws reaching flower 3, and non-black big flower	80-76 colours	Can carve medium diamonds and large diamonds more than 1 Karat	The size is large but both the quality and the colours can not reach the third grade

**According to "gems and Jades" of Liang Yuong Ming published by the Geological publishing house*

IV. Appraisal Features of Diamond

Because of the high price of diamond, fakes of various kinds are frequently met. Fakes are usually in two kinds of material: glass and artificial spinelle (artificial crystalline stone). Real diamond glimmers brilliantly, shedding its light in all directions; the lustre and brightness of fakes cannot match diamonds because the dioptre rate is low, and thus do not possess the "fire" of diamonds (ie. dazzling radiance). Although being worn for a long time, real diamond will not have any damage; fakes usually have different frosted form. If diamond pen is used to scratch the sides of the base petal in order to test the genuineness, it is even more effective. However, attention must be paid as not to damage the beauty of the gem, and this method should not be used unless under absolute necessity. There are certain rules to the process of real diamonds: a fixed proportion between the diameter and the thickness (ie. between 100:55-60), and the angle is also fixed. Facets are smaller, usually cut into 57 or 58 facets. Fake diamonds use greater thickness in general in order to increase the radiance, but it disturbs the proportion of work. Besides "the degree of perfection" is different. For real diamonds, there is always some kind of flaw, but fake diamonds are always "perfect". If there is enough equipment, fake diamond will show its true colour under the inspection of X-ray.

V. Geological Features of Diamond's Origin

Diamonds are produced in two situations:

One in the Kimbelite or Lamproite as original diamond. The other one is produced in the placer deposit these two sorts of occurrence are discovered in Xinjiang.

Chapter Four Jades

Section One Nephrite (Hotan Jade and Jasper)

I. General Introduction

Nephrite in Xinjiang can be divided into Hotan jade and jasper, and Hotan jade is the most famous. Nephrite is composed of tremilite microcrystal aggregates. Its lustre is soft and clear, its texture is delicate and fine, and is generally loved by people. Hotan has been exploited since the New Stone Age. For a long time it has been used in making sacrificial vessels, ornaments, musical instruments, objects of admiration and sacrificial utensils. It is also a precious currency and played an important part in the economic development of our country during the beginning of the feudal society.

The Shang Dynasty was an important period for the technological development of jade carving, and it set a foundation for the technological development of jade objects. Afterwards, there were the sacrificial vessels of Zhou, the imperial zeal of Qin, the jade clothes of Han, the jade lotus flower of Tang, the jade Guanyin of Song, the Grand Jade Tub from the Dushan of Yuan and the Zi Gang Seeing His Son Off of Ming. In the Qing Dynasty, the production of jade objects was even more magnificent. The jade hill of "Yu the Great, Tamer of Floods" (colour photograph 27) now displayed in Beijing's. Palace Museum is of great momentum and it is the largest jade object in the history of our country. The jade objects of these dynasties are all carved in Xinjiang's Hotan jade.

After the founding of the People's Republic of China, great importance has been attached to the exploitation of Xinjiang's nephrite, especially Hotan jade. With the development of the national economy and the international contact, there is an increase demand both in the domestic and the market abroad, on the handicraft of Xinjiang's Hotan. In order to meet this need, general survey and the work of deposit-finding have been reinforced and obtained a definite result. At the same time, monographic studies had been conducted in certain key mining areas and the conclusion is that there is an optimistic exploitation future. At present, certain mines in Xinjiang have been fixed and modern exploitation has started. It provides a large amount of fine quality materials for jade-carving factories in the country. After technological processing, these exquisite handicrafts gain large amount of foreign exchange for the country and enjoy great artistic reputation internationally.

II. Physical and Chemical Properties

Xinjiang's nephrite is mainly combined by tremolite aggregates of fabric shape, long column

shape, and blanket shape. Some nephrites belong to tremolite and actinolite isomorphous series, and as a result appear in light green in colour. There are two types of nephrite deposits formed by different causes. Hotan jade belongs to regional contact metamorphic type; jasper belongs to the country rock xenolith in the ultrabasic mass formed by contact matasomatis of ultramafite pastmagmatic hydrothermal solution. As a result, the associated minerals of the two different types of nephrites have their divergence. The following is the characteristics of the chemical composition, the infrared spectrum, the physical nature, the optical nature and the microscopic:

1. Chemical Composition of Nephrite

The analysis information of the chemical composition of different varieties of nephrites of Xinjiang and that of countries abroad is in chart 12.

(i) From the chart, we can see that the white jade, greyish white jade, grey jasper, jasper jade and black jade are listed in order. The other chemical composition have the following change regulations: with the deepening of the colour of jade.

(1) the amount of ferric oxide increase;

(2) there is a decreasing trend of oxide calcium and magnesium, but it is not very obvious;

(3) there is a general rising up of oxide aluminium, but for black jade, when compared to jasper jade, it has a lowering tendancy;

(4) jasper jade is different from other varieties of jade and has special ultramafic elements like nickel , cobalt and chromium.

(ii) The chemical composition of Xinjiang's nephrite and that of countries abroad are basically similar, but still have a slight difference:

(1) in the amount of silica contained, Xinjiang's nephrite is similar to that of Canadian and USSR's nephrite has a larger change range of silica.

(2) The amount of alumina contained in USSR's nephrite is slightly more than the nephrite of Xinjiang and that of Canada. It is probably related to the larger amount of chlorite impurities;

(3) the feric oxide content of Xinjiang's nephrite is higher than that of USSR and Canada, the highest amount contained may reach 2.16%;

(4) the change range of ferric oxide contained in Xinjiang's nephrite is higher, the amount from 0.12-8.08%;

(5) for the amount of manganese contained, Xinjiang's nephrite is similar to that of oxide USSR's, but Canada's nephrite has a higher amount;

(6) the amount of oxide magnesium and oxide calcium in Xinjiang's nephrite is higher than that of USSR's and Canada's;

(7) the amount of oxide natrium and potassium in Xinjiang's nephrite is between USSR's and Canada's, among them the highest is USSR's nephrite;

(8) the jasper of Xinjiang and the nephrite of Canada both contain oxide chromium and nickel, it shows that they may have similarities in the cause of formation. According to the analysis of electronic probe, both Hotan jade and jasper contain small – little amount of oxide chromium. According to the numerical value calculation of the above nephrite sample's chemical elements, the minerals belong to fremolite group. Although their species and occurrences are different, the difference in their chemical composition is not much.

The amount of trace elements contained in Xinjiang's nephrite varies according to their species and genetical types. See chart 13. From chart 13, we know that it is common that Xinjiang's nephrite contains oxide maganese, the amount is from 0.01%>1%; about half of the Hotan jade contains 0.01%-0.04% of copper; beryllium is commonly distributed in Hotan jade, its amount is 0.0005%-0.0002%; Xinjiang's nephrite usually contains chromium, nickel and cobalt, they are all special elements containing ultrabasic rock. It shows that the deposit's formation is related to ultrabasic mass; bismuth is commonly distributed in Hotan jade; nephrite from Arjin Shan contains elements like zinc, germanium and gallium. The appearance of these trace elements obviously shows that it is related to the formation of the mines.

We had conducted an electronic probe analysis on Kunlun white jade and Tianshan Jasper jade and the result is in chart 14. Among the analysis data, the amount of MgO and CaO is higher than that of the chemical analysis result, especially that of white jade; the amount of SiO_2 contained is low; to have a high FeO content is one of the characteristics of jasper jade, showing that the tremolite constituents in jasper jade incline to the extremity of actinolite, and as result shows hues of green.

2. The Mineral Constituents of Nephrite and Its Optical Features

Xinjiang's nephrite, according to the observation of polarizing microscope, is mainly the minerals of tremolite – actionlite group,with tremolite occupying the principal part. It is generally in blanket shape, intricating fabric shape or interwoven in fine cloth fragment crystal stock. The associated minerals are diopside, serpentine, clinozoisite, apatite, magnetite sand, titanite (leucosxenization), chlorite, chrome spinel,grossularite, millerite, magnetic pyrite, graphite, chromium chlorite, and individual monazite, etc.

Optical features of tremolite nephrite: refractive indices Np=1.6168, Nm=1.6280, Ng=1.6340, Ng∧C=14° ±; biaxial crystal and negative character (–) 2V bigger. The extinction pattern of blanket shape tremolite:

After being tested by transmissive electronic microscope and scanning electronic microscope, it was found that most of the tremolite crystals are aggregates of needle column shape, and have the following characteristics:

(1) Sheep greasy jade: – its tremolite crystal is extremely small with the size0.0006×0.033 – 0.001 ×0.001mm. Bigger ones are 0.0086 × 0.0073mm. The main characteristic is that the mineral structure is more even, as a result, a better quality. (As figure 7,8).

(2) White Jade – white jade has two sizes, the crystal is aggregates in plank column shape and long column shape. On the whole, the tremolite crystal in white jade is more even, with large crystals mixed in it (as in figure 9.10), and the rough white jade has larger size (as in figure 11.12). The size of white jade is from 0.009 × 0.002mm to 0.018 × 0.006mm. In rough white jades, there are tiny tremolite crystals, of which the larger crystals are thicker plate crystal stock.

Chart 12. Chemical components of Xinjiang's and forcign nephrite

No.	Nephrite Species	Occurrence	Oxide content (%)									
			SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	M O	CaO	Na_2O	K_2O	NiO
1	White jade	Kunlun Mts.	56.15	0.08	1.02	0.62	0.78	0.18	24.08	13.20	0.21	0.10	
2	Sheep fat colour jade	Kunlun Mts.	56.08	0.000	0.79	0.50	0.78	0.07	24.82	13.23	0.21	0.10	
3	White jade	Kunlun Mts.	56.97	0.00	0.75	0.31	0.60	0.12	24.99	12.73	0.22	0.22	
4	White jade	Kunlun Mts.	57.40	0.00	1.10	0.13	0.54	0.06	24.42	12.77	0.16	0.27	
5	White jade	Kunlun Mts.	56.95	0.00	0.52	0.29	0.12	0.00	25.42	14.14	0.24	0.00	
6	White jade	Arjin Mts.	55.00	0.03	1.27	0.3	0.82	0.03	21.30	17.41	0.24	0.02	
7	White jade	Kunlun Mts.	57.31		0.56	0.11	0.73		22.69	13.30	0.42	0.12	
8	Green white jade	Kunlun Mts.	55.19	0.00	1.42	0.53	0.68	0.08	23.83	13.20	0.23	0.23	
9	Green white jade	Kunlun Mts.	56.97	0.06	0.94	0.17	1.00	0.15	23.92	13.65	0.23	0.23	
10	Green jade	Kunlun Mts.	53.34	0.08	3.54	1.28	1.84	0.18	21.78	12.73	0.23	0.23	
11	Green jade	Kunlun Mts.	56.53	0.00	0.94	0.30	1.24	0.12	24.22	12.54	0.23	0.13	
12	Green jade	Kunlun Mts.	56.23	0.00	1.10	0.18	1.38	0.12	24.02	12.50	0.24	0.24	
13	Green jade	Kunlun Mts.	55.63	0.03	2.43	0.12	1.86	0.10	24.37	11.33	0.20	0.15	
14	Green white jade	Kunlun Mts.	57.60	0.23	0.94	0.04	0.85	0.06	24.37	12.62	0.20	0.22	
15	Green white jade	Kunlun Mts.	57.13	0.00	0.75	1.06	0.77	0.06	24.91	12.92	0.32	0.00	
16	Green jade	Kunlun Mts.	56.76	0.00	0.97	2.60	1.88	0.15	23.60	13.25	0.28	0.00	
17	Green jade	Arjin Mts.	56.86	0.11	2.27	0.61	1.5		21.34	13.10	0.36	0.3	
18	Black jade	Kunlun Mts.	54.75	0.00	1.34	0.14	3.92	0.04	24.08	12.84	0.23	0.10	
19	Jasper	Tian Shan Mts.	57.00	0.018	0.67	1.48	2.85	0.07	22.33	12.68	0.00	0.08	0.16
20	Jasper	Tian Shan Mts.	55.70	0.027	0.73	2.16	2.40	1.28	22.57	11.84	0.06	0.10	0.05
21	Jasper	Tian Shan Mts.	54.00	0.01	1.82	1.43	4.10	0.11	22.13	11.39	0.21	0.06	0.22
22	Jasper	Tian Shan Mts.	52.33	0.01	3.21	0.70	5.14	0.12	22.21	9.35	0.16	0.06	0.22
23	Jasper	Tian Shan Mts.	52.64	0.18	3.31	0.07	4.33	0.02	23.15	10.80	0.24	0.04	0.08
24	Nephrite	Ospin mine USSR.	55.12	Trace amount	1.37	0.38	5.57	Not being tested	21.54	12.72	0.35	0.10	
25	Nephrite	Ospin mine USSR.	54.54		0.75	0.01	4.35		22.84	12.85	0.41	0.81	
26	Nephrite	Ospin mine USSR.	53.85		1.37	0.75	6.46		21.14	13.68	0.37	0.21	
27	Nephrite	Ospin mine USSR.	57.97	0.05	1.16	0.40	4.17	0.14	22.39	12.00	0.09	0.09	
28	Nephrite	Ospin mine USSR.	56.20		1.20	0.36	3.86	0.19	23.06	12.36	0.16	0.14	
29	Nephrite	Ospin mine USSR.	56.39	Trace amount	1.10	0.78	4.10	Not being tested	21.69	12.78	0.04	0.03	
30	Nephrite	Ulanhot mine	48.62		6.35	0.33	6.37		22.60	10.30	0.43	0.46	
31	Nephrite	Ulanhot mine	56.60		0.70	0.78	3.65		22.89	12.23	0.04	0.03	
32	Nephrite	Ulanhot mine	55.70		1.08	1.00	3.38		22.83	12.01	0.05	0.09	
33	Nephrite	Palam mine	56.34	0.09	1.78	0.31	4.11	0.07	21.67	12.65	0.45	0.03	
34	Nephrite	Palam mine	55.79	0.08	1.88	0.81	3.58	0.09	21.40	12.57	0.37	0.01	
35	Nephrite	Palam mine	56.70	0.08	0.70	0.34	3.70	0.12	23.73	12.66	0.20	0.10	
36	Nephrite	Palam mine	52.48	0.45	2.24	1.34	5.64	0.11	21.79	10.87	0.16	0.10	
37	Nephrite	Palam mine	55.10		1.27	1.15	3.25	0.12	22.62	14.15			
38	Nephrite	Palam mine	54.83		1.43	1.38	3.36		23.01	12.60	0.03	0.01	
39	Nephrite	Bickner mine	52.08	0.45	3.4	0.59	5.67	0.16	20.64	11.25	0.81	0.25	
40	Nephrite	Harlov mine	53.82	0.12	0.53	1.66	2.85	0.07	25.28	8.68	0.10	0.13	
41	Nephrite	Jorolansmuhl, Poland	57.58	0.10	1.35	0.15	4.02	0.15	20.65	13.10	0.12	微量	
42	Nephrite	Cassiar Canada	52.78	0.01	2.72	1.12	4.74	0.41	21.20	12.20	0.05	0.03	0.20
43	Nephrite	Dease lake Canada	53.24		3.04	1.11	3.31	0.10	23.20	10.40	0.03	0.02	0.17
44	Nephrite	Alice shea, Creek, Canada	55.12	0.01	1.92	0.95	3.31	0.08	21.80	12.10	0.14	0.10	0.12
45	Nephrite	Mount Ogaen, Canada	56.32	0.01	1.76	0.63	3.02	0.09	21.40	12.90	0.10	0.06	0.14
46	Nephrite	Hell Creek Canada	56.64	0.01	1.12	0.80	3.16	0.18	21.40	13.00	0.06	0.05	0.11
47	Nephrite	Brett Creek, Canada	56.50	0.01	1.28	0.55	3.31	0.13	21.80	13.20	0.06	0.04	0.08
48	Nephrite	Noel Creek, Canada	54.96	0.02	2.64	1.04	3.45	0.08	21.20	12.00	0.05	0.03	0.18
49	Nephrite	Frances lake, Canada	56.18	0.02	1.88	0.72	3.16	0.10	21.40	12.64	0.05	0.03	0.14
50	Nephrite	Canada	55.22	0.01	2.04	0.86	3.43	0.15	21.67	12.31	0.07	0.04	0.14
51	Nephrite	Alaska U.S.	58.11		0.24	5.44	0.38	Trace amount	21.79	12.01			
52	Nephrite	New Zealand	55.0	0.04	0.90	1.60	3.80	0.19	21.80	11.80	0.20	0.20	
53	Nephrite	Brazil	59.79	0.23	0.88	0.33	0.96	0.10	24.31	12.52	0.35	0.06	
54	Nephrite	Australia	56.0		0.78	(7.91)			20.3	12.4	0.067	0.16	
55	Nephrite	Wyoming, U.S.	54.10	0.01	3.30	(12.30)		0.20	20.3	10.30		0.20	

Note: 24-55 quoted from Kolesnik, Yu, N, "Nephrites of Siberia" (1970) and Leamina SF "Jade in Canada" (1978).

Chart 12. Chemical components of Xinjiang's and foreign nephrite

No.	Naphrite Species	Occurrence	Oxide Content (%)										
			CoO	P_2O_5	Cr_2O_3	SO_3	CO_2	Cl	H_2O^+	H_2O^-	F^+	Ing. loss	Total
1	White jade	Kunlun Mts.		0.08		0.11	1.20					3.22	101.03
2	Sheep fat colour jade	Kunlun Mts.		0.03		0.16	0.56					3.07	100.4
3	White jade	Kunlun Mts.		0.03		0.24	0.36					2.90	99.87
4	White jade	Kunlun Mts.				0.09							96.94
5	White jade	Kunlun Mts.		0.044							0.15	2.46	100.05
6	White jade	Arjin Mts.											96.42
7	White jade	Kunlun Mts.					0.19		3.56	0.18			99.31
8	Green white jade	Kunlun Mts.		0.03		0.27	0.78					3.68	100.15
9	Green white jade	Kunlun Mts.		0.05		0.27	0.36					2.64	100.64
10	Green jade	Kunlun Mts.		0.08		0.11	1.20					4.02	100.64
11	Green jade	Kunlun Mts.		0.03		0.11	0.39					3.17	99.95
12	Green jade	Kunlun Mts.		0.03		0.25	0.24					3.32	99.85
13	Green jade	Kunlun Mts.				0.13	0.39		2.36				99.09
14	Green white jade	Kunlun Mts.				0.14	0.42		1.76				99.45
15	Green white jade	Kunlun Mts.		0.062						0.145		2.96	100.32
16	Green jade	Kunlun Mts.		0.062							0.17	2.32	100.15
17	Green jade	Arjin Mts.											96.49
18	Black jade	Kunlun Mts.		0.06		0.23	1.43					1.86	101.02
19	Jasper	Tian Shan Mts.	0.009	0.014	0.26	0.11	2.36					2.74	102.99
20	Jasper	Tian Shan Mts.	0.011	0.031	0.26	0.11	2.43					3.17	102.65
21	Jasper	Tian Shan Mts.	0.01	0.02	0.35	0.05	0.20		4.20				100.40
22	Jasper	Tian Shan Mts.	0.013		0.30	0.06	0.50		5.35				99.73
23	Jasper	Tian Shan Mts.	0.004	0.09	0.26	0.09							95.30
24	Nephrite	Ospin mine USSR.		Not					Not			2.36	99.81
25	Nephrite	Ospin mine USSR.		being					being			2.36	99.19
26	Nephrite	Ospin mine USSR.		tested					tested			2.70	100.52
27	Nephrite	Ospin mine USSR.							2.43			0.02	100.91
28	Nephrite	Ospin mine USSR.							2.47			0.15	100.15
29	Nephrite	Ospin mine USSR.	0.03						1.71			2.38	101.03
30	Nephrite	Ulanhot mine							Not being tested			4.71	100.17
31	Nephrite	Ulanhot mine	0.04						1.78			2.82	101.56
32	Nephrite	Ulanhot mine	0.02						2.25			3.19	101.60
33	Nephrite	Palam mine				0.07			2.48				100.95
34	Nephrite	Palam mine							2.94				99.52
35	Nephrite	Palam mine							0.12			2.37	100.82
36	Nephrite	Palam mine	0.06			0.02			0.30			3.96	99.52
37	Nephrite	Palam mine							Not being tested			2.10	99.76
38	Nephrite	Palam mine	0.03						1.90			3.20	101.78
39	Nephrite	Bickner mine										4.60	99.94
40	Nephrite	Harlov mine	0.01						1.27			5.78	100.80
41	Nephrite	Jorolansmuhl, Poland							2.61				99.83
42	Nephrite	Cassiar Canada			0.32		0.004		3.94	0.22	0.05		99.97
43	Nephrite	Dease lake Canada			0.26		0.004		4.81	0.26	0.06		100.00
44	Nephrite	Alice shea, Creek, Canada			0.18		0.01		3.84	0.32	0.03		100.00
45	Nephrite	Mount Ogaen, Canada			0.19		0.001		3.22	0.26	0.03		100.12
46	Nephrite	Hell Creek Canada			0.16		0.01		3.20	0.18	0.02		100.09
47	Nephrite	Brett Creek, Canada			0.16		0.04		2.88	0.06	0.02		100.07
48	Nephrite	Noel Creek, Canada			0.28		0.01		3.50	0.60	0.03		100.06
49	Nephrite	Frances lake, Canada			0.20		0.01		2.98	0.46	0.03		99.99
50	Nephrite	Canada			0.22		0.01		3.55	0.30	0.03		100.15
51	Nephrite	Alaska U.S.								1.78			99.75
52	Nephrite	New Zealand							3.16	1.16			99.85
53	Nephrite	Brazil							2.10	0.32			101.95
54	Nephrite	Australia								1.89			99.6
55	Nephrite	Wyoming, U.S.											*100.80*

Note: 24-55 quoted from Kolesnik, Yu, N, "Nephrites of Siberia" (1970) and Leamina SF "Jade in Canada" (1978)

Chart 13. Comparison table between the trace element content of Xinjiang and foreign nephrite

No.	nephrite species	occurrence	Trace element content (%)														
			Cu	Pb	Cr	Ni	Co	Sn	Mn	Bi	Ag	Be	Sr	Sc	Ba	Ti	V
1	White jade	Kunlun Mts.	0.04	–	–	–	–	–	0.1	>0.01	–	0.0015					
2	Sheep fat colour jade	Kunlun Mts.	–	–	–	–	–	–	0.05	>0.01	–	0.0005					
3	White jade	Kunlun Mts.	<0.01	–	–	–	–	<0.001	0.1	>0.01	–	0.001					
4	White jade	Kunlun Mts.	–	–	–	–	–	<0.001	0.01	–	–	–					
5	Green white jade	Kunlun Mts.	0.1	–	<0.01	–	–	–	0.05	>0.05	–	0.0015					
6	Green white jade	Kunlun Mts.	–	–	–	–	–	<0.001	0.07	>0.05	–	0.0015					
7	Green jade	Kunlun Mts.	0.04	0.005	–	–	–	–	0.1	>0.01	–	0.001					
8	Green jade	Kunlun Mts.	–	–	–	–	–	–	0.07	>0.01	–	0.002					
9	Green jade	Kunlun Mts.	–	–	–	–	–	–	0.05	>0.01	–	0.002					
10	Green jade	Arjin Mts.	–	–	–	–	–	–	0.05	–	–	0.002					
11	Black jade	Kunlun Mts.	<0.01	–	–	<0.005	–	–	–	–	–	0.001					
12	Brown sugar jade	Arjin Mts.	–	–	–	–	–	–	0.3	–	–	0.003					
13	Jasper	Tian Shan Mts.	–	–	0.5	0.3	0.02	–	0.05	<0.001	–	–					
14	Jasper	Tian Shan Mts.	–	–	0.30	0.2	0.015	–	>1	–	0.002	–					
15	Nephrite	Cassiar, Canada	0.005		0.22	0.16	0.0054		0.39			0.0002	Trace	0.0011	0.0027	0.0039	0.0051
16	Nephrite	Dease lake, Canada	0.005		0.18	0.13	0.0058		0.068			0.0002	0.0017	0.00077	0.0014	0.0014	0.0038
17	Nephrite	Alice shea, Creek, Canada	0.005		0.12	0.094	0.0042		0.054			0.0002	0.003	0.00062	0.0035	0.0042	0.0033
18	Nephrite	Mount Ogden, Canada	0.005		0.13	0.11	0.0033		0.072			0.0002	0.0021	0.00067	0.0043	0.0023	0.0030
19	Nephrite	Hell Creek, Canada	0.005		0.11	0.085	0.0035		0.015			0.0002	0.0050	0.00055	0.0018	0.0047	0.0043
20	Nephrite	Brett Creek, Canada	0.005		0.11	0.06	0.0024		0.091			0.0002	0.0027	0.0006	0.0018	0.004	0.0029
21	Nephrite	Noel Creek, Canada	0.005		0.19	0.14	0.0054		0.060			0.0002	0.0017	0.0079	0.0047	0.0043	0.0035
22	Nephrite	Frances lake, Canada	0.005		0.14	0.11	0.0039		0.068			0.0002	0.0019	0.00063	0.0044	0.0073	0.0032

Note: 15-22 quoted from S.F. leaming "Jade in Canada"

Chart 14. Results of electronic probing analysis of Xinjiang's nephrite

No.	Name	Occurrence	Analysed Components										
			SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	MnO	Na_2O	K_2O	Cr_2O_3	total in all
1	Jasper	Tian Shan Mts.	52.00	–	0.02	5.07	25.24	15.02	0.28	–	–	–	97.63
2	Jasper	Tian Shan Mts.	54.47	0.07	0.14	4.26	24.70	14.00	0.03	–	0.02	0.11	97.80
3	Jasper	Tian Shan Mts.	53.72	0.08	0.11	4.45	24.88	14.17	0.17	0.03	–	0.04	97.65
4	Jasper	Tian Shan Mts.	55.31	–	0.15	4.12	24.17	13.71	–	0.07	0.02	0.35	97.86
5	White Jade	Kunlun Mts.	51.13	0.09	0.12	0.29	28.82	16.58	–	0.04	0.04	0.33	97.44
6	White Jade	Kunlun Mts.	49.05	0.08	0.60	0.38	30.65	16.36	–	–	0.07	0.07	97.26
7	White Jade	Kunlun Mts.	52.61	–	0.10	0.23	27.89	16.42	–	0.03	–	0.18	97.46
8	White Jade	Kunlun Mts.	51.53	0.02	0.06	0.15	29.21	16.19	0.05	–	–	0.36	97.57
9	White Jade	Kunlun Mts.	50.35	–	0.76	0.42	29.94	15.48	0.16	0.05	0.11	0.26	97.53

* (1) Analysed by the Institute of Geology and Mineral Resources, Chinese Academy of Geological Science

(2) Total analysis except water. Note: 15-22 quoted from S.F. leaming "Jade in Canada"

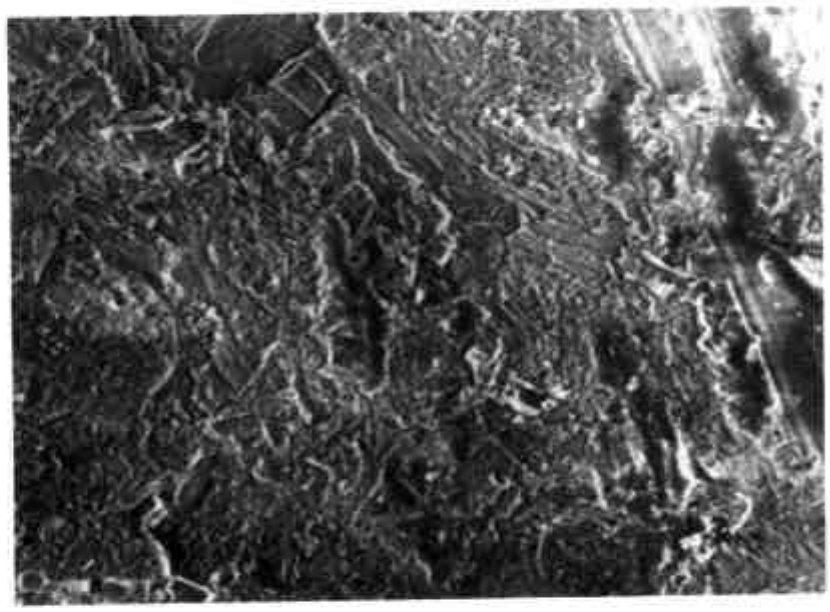


Figure 7 The scanning electronic microscopic photo of sheep greasy jade
The morphology of tremolite crystal 2250 ×

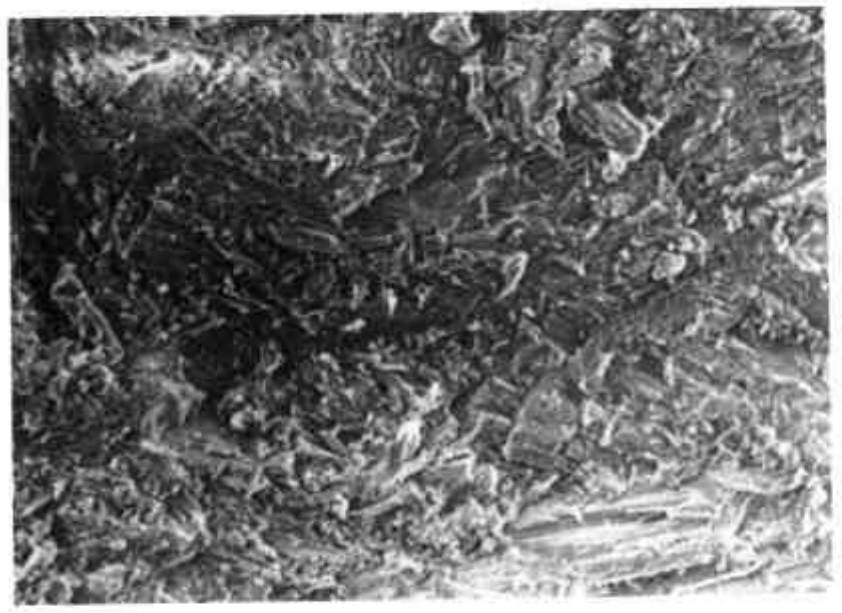


Figure 8 Scanning electronic microscopic photo of sheep greasy jade
morphology of Tremolite crystal 1500×

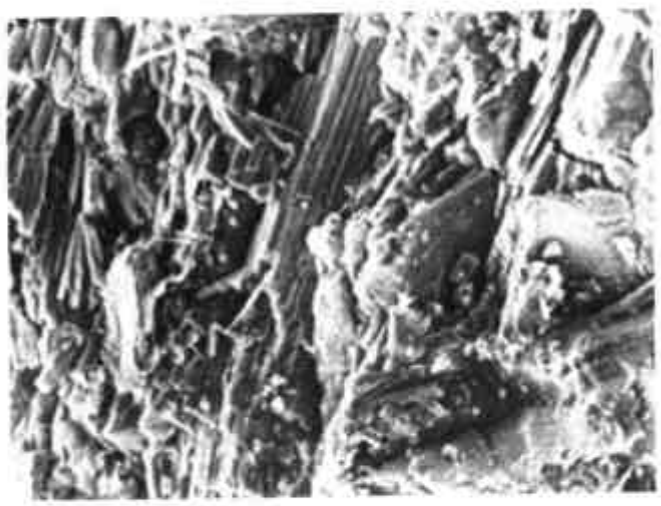


Figure 9 Scanning electronic microscopic photo of white jade
morphology of Tremolite crystal 4500×

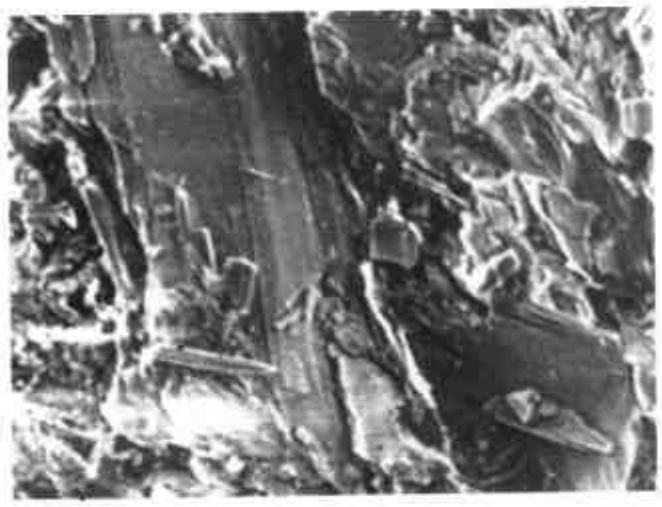


Figure 10 Scanning electronic microscopic photo of white jade
morphology of Tremolite crystal 4500×

(3) Greyish white jade – the interim type of white jade and grey jasper. There are larger crystals in tiny tremolite crystals, its phenocrysts are in long column shape and have wavy edges. The size is 0.0006 x 0.002 – 0.014 × 0.004mm. It shows that its structure is not even, some are as fine as white jade, and some like column shape crystals in small granular shape. As in figure 13.14.

(4) Green jade: It is constituted by tiny tremolites, but some are distributed in lump shape. It shows that its structure is not even, as in figure 15.16. The size of tremolite is 0.0013 × 0.00053 – 0.006 ×

0.004mm. It shows that the quality is less than white jade and greyish white jade. The size of the lump is 0.01×0.013mm. Larger ones are 0.04×0.26mm.

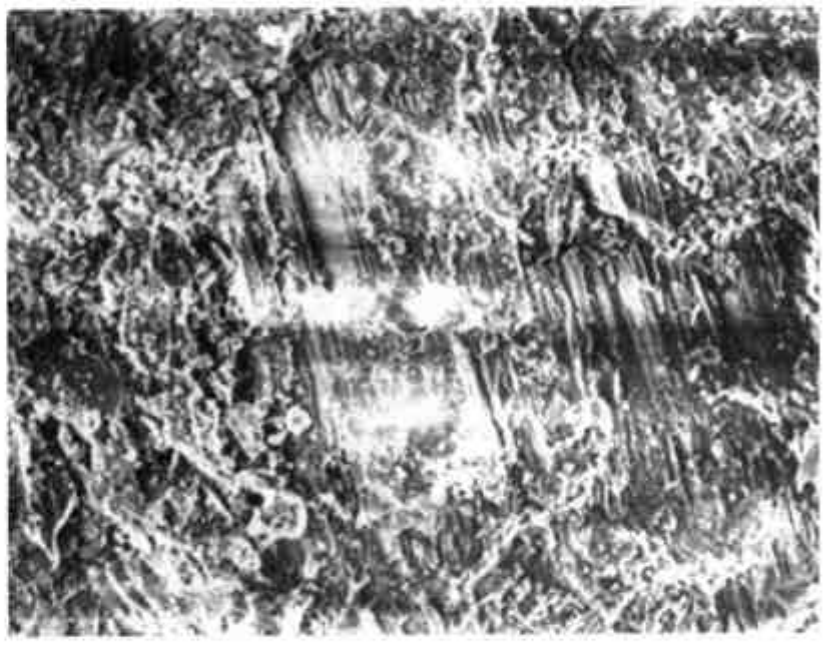


Figure 11 Scanning electronic microscopic photo of rough white jade morphology of Tremolite crystal 2000×

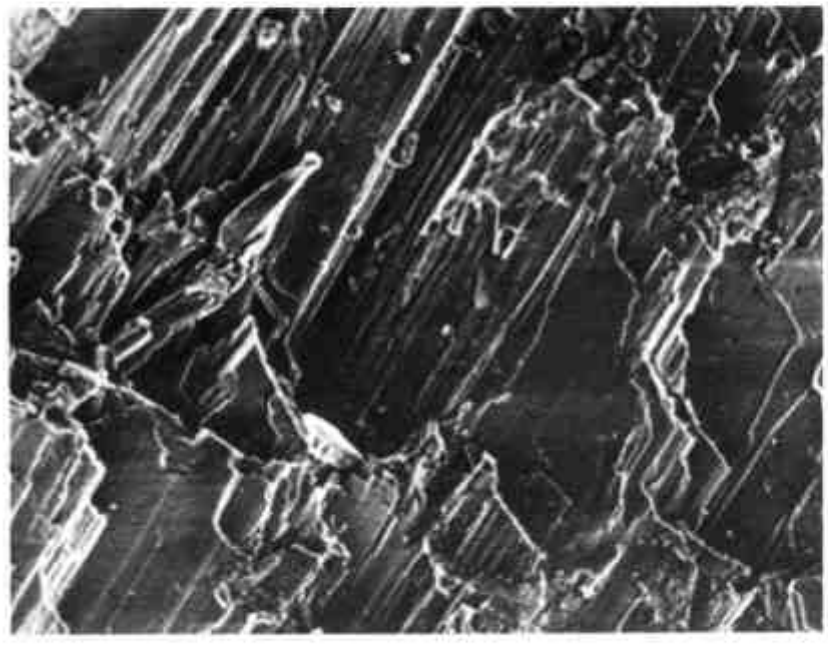


Figure 12 The scanning electronic microscopic photo of rough white jade morphology of Tremolite crystal 1500×



Figure 13 The scanning electronic microscopic photo of greyish white jade morphology of Tremolite crystal 1500×

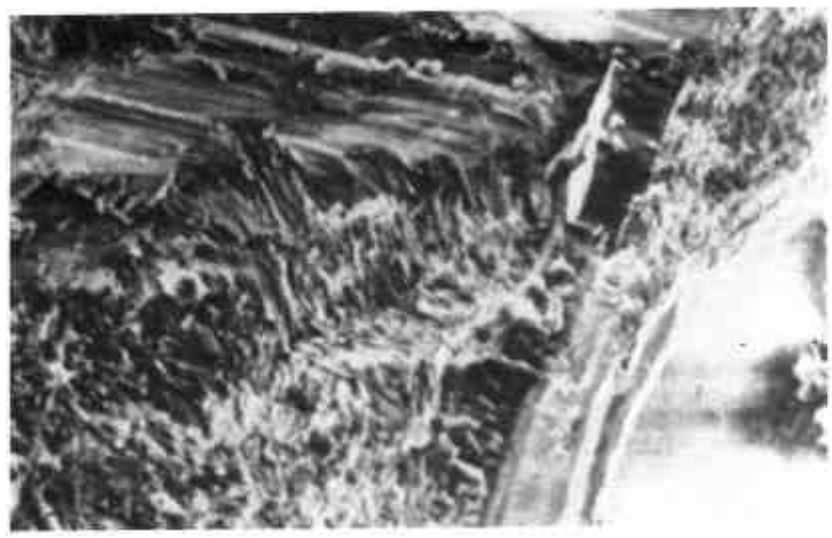


Figure 14 The scanning electronic microscopic photo of greyish white jade morphology of Tremolite crystal 1500×

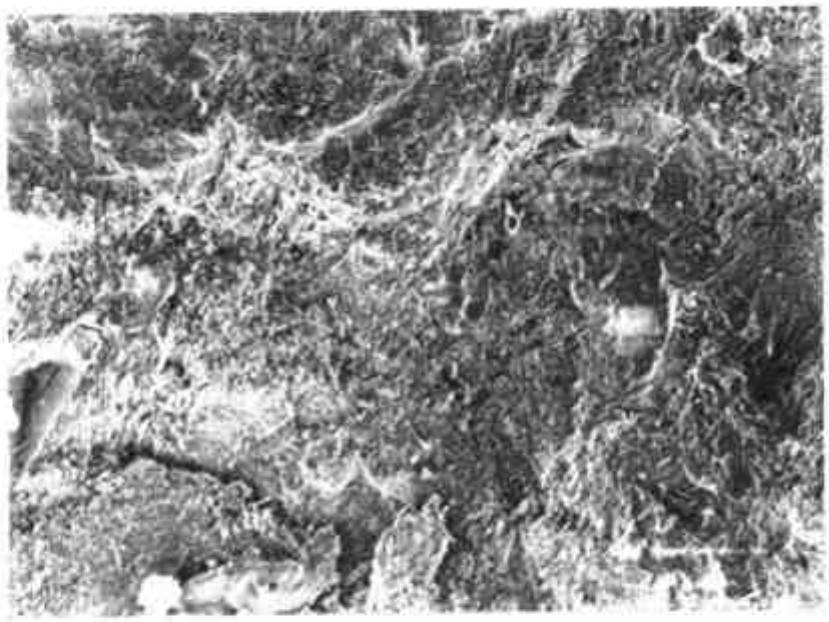


Figure 15 The scanning electronic microscopic photo of green jade
morphology of Tremolite crystal 1500×

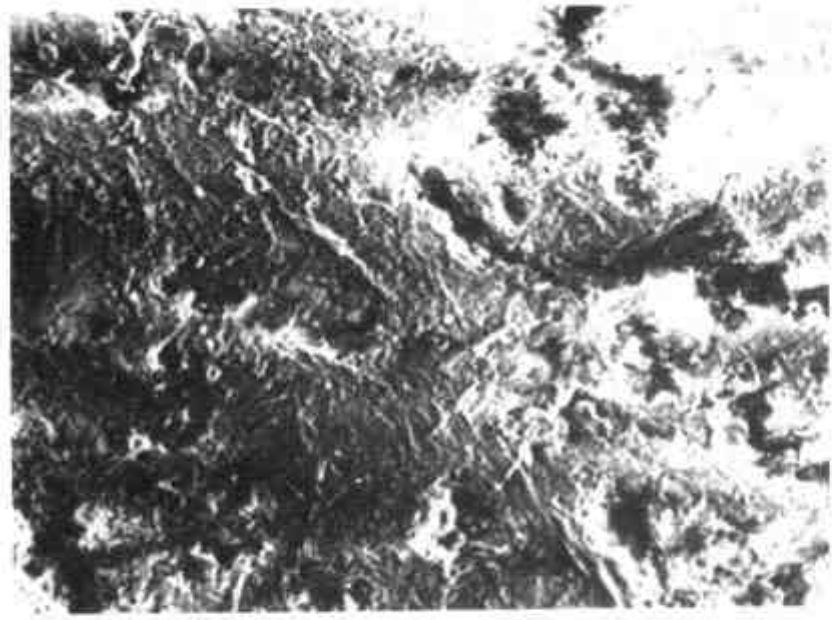


Figure 16 The scanning electronic microscopic photo of green Jade.
morphology of Tremolite crystal 1500×

(5) Black jade – The structure of tremolite is not even, and is mainly in column shape and granular shape. There are graphite filled inside, so the jade appears black in colour, as in figure 17. The size of small tremolites are 0.00033 × 0.0033mm, (large ones are 0.008 × 0.0053mm, long plank are 0.0086 × 0.0033mm.) that of graphite is 0.01 × 0.0066mm. Some graphite are distributed among the tremolites in order to fill them.

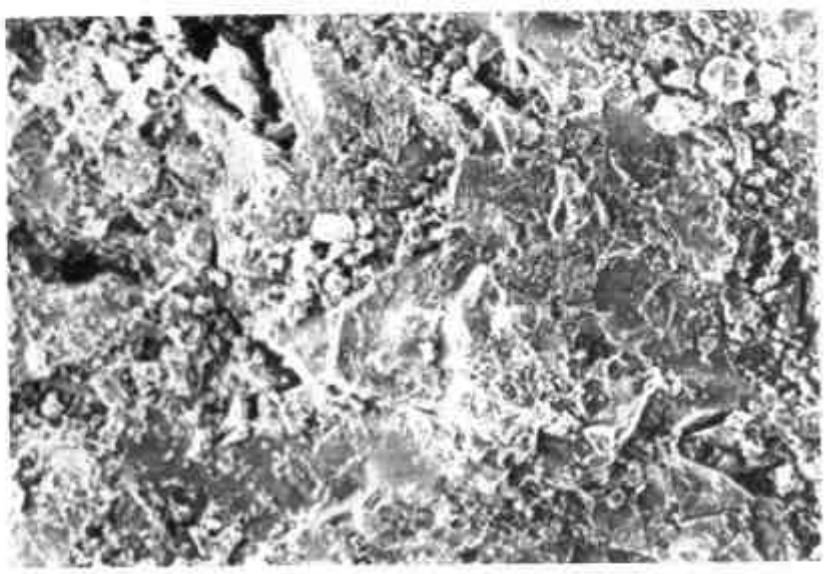


Figure 17 The scanning electronic microscopic photo of black jade
morphology of Tremolite crystal 1500×



Figure 18 The scanning electronic microscopic photo of brown sugar jade
morphology of tremolite crystal 1500×

(6) Brown sugar jade: Sugar jade and white jade appear to have interior change and their relation is shown in figure 18.19.The tremolite size inside brown sugar jade is 0.0066×90.0053mm. It is an aggregate of slim and long column shape and among it there are black limonite. The size of the tremolite inside white jade is the same as brown sugar jade, showing that the red or brownish yellow is due to the pollution of tremolite by ferric oxide.



Figure 19 The scanning electronic microscopic photo of brown sugar jasper
(on the adjoining line of white jade and brown sugar jade)
morphology of tremolite crystal 3000×

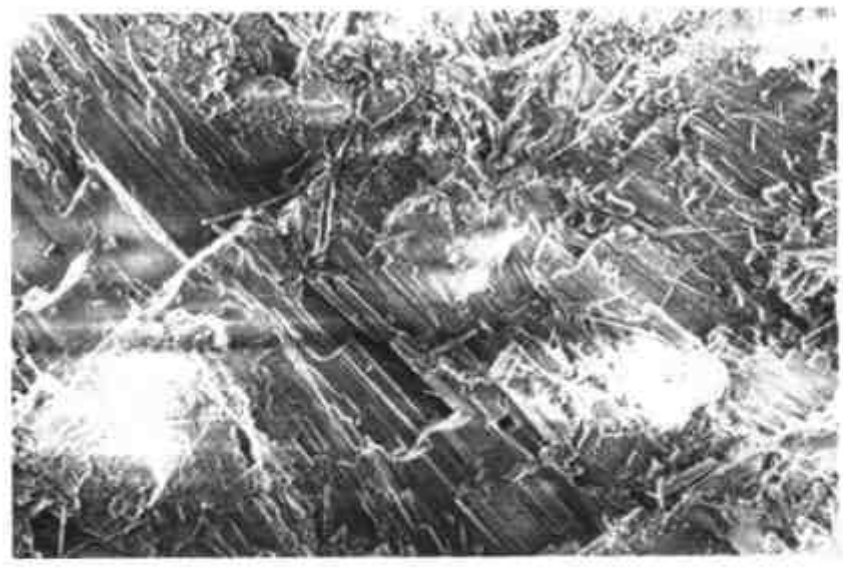


Figure 20 The scanning electronic microscopic photo of jasper jade
morphology of Tremolite crystal 1500×

(7) Jasper jade: The structure of tremolite is not even, some are crystals in long plank shape, and among them are set with tiny crystals of tremolite. There are other tremolites in lumps and pieces, and some in bending shape, as shown in figure 20.21.22. The size of the tremolite is 0.0002×003mm, (upto 0.05×0.0026mm) and that of lumps and pieces is 0.053×0.036mm. It shows that the quality of jasper is inferior to that of Hotan jade.

(8) Jin-shan jade – The tremolite structure is not even, and is distributed in lumps and porphyritic shape. The size is 0.00033× 0.0066mm., some can reach 0.0013 × 0.01mm. The size of the lumps is 0.0013×0.006mm, as in figure 23.24. Its sample is as colour illustration 43.

For transmissive electronic microscopic observation, only white jade, green jade and jasper jade are chosen. Their minerals are all crystals in long column shape and tiny column shape, as shown in figure 25.26.27.28.

The x-ray analysis result of nephrite's powder crystal shows that white jade, greyish white jade and green jade have basically the same numerical value, and belong to tremolite. There is some difference for the analytic value of jasper jade, but it belongs to tremolite too. (See chart 15). The condition of experiment: target: Fe; camera diameter: 57.3mm; voltage: 38KV; electric current: 20mA; the exposure time is 6 hours.

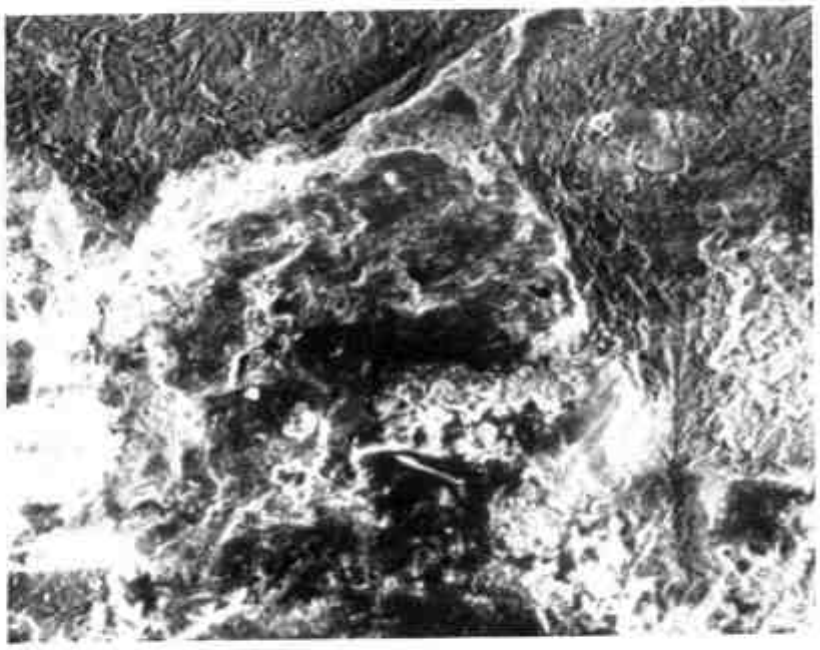


Figure 21 The scanning electronic microscopic photo of jasper jade
morphology of Tremolite crystal 1500×

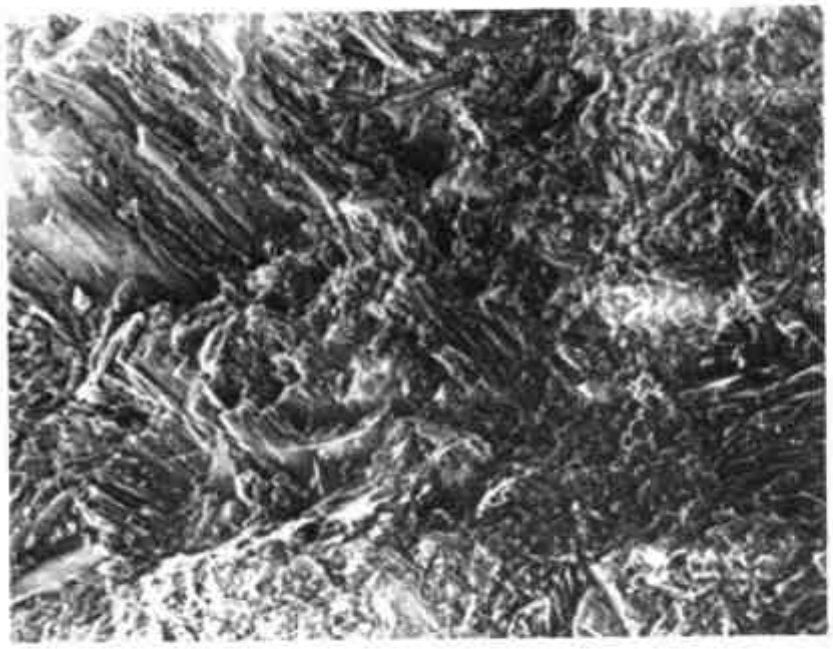


Figure 22 The scanning electronic microscopic photo of jasper jade
morphology of Tremolite crystal 1500×

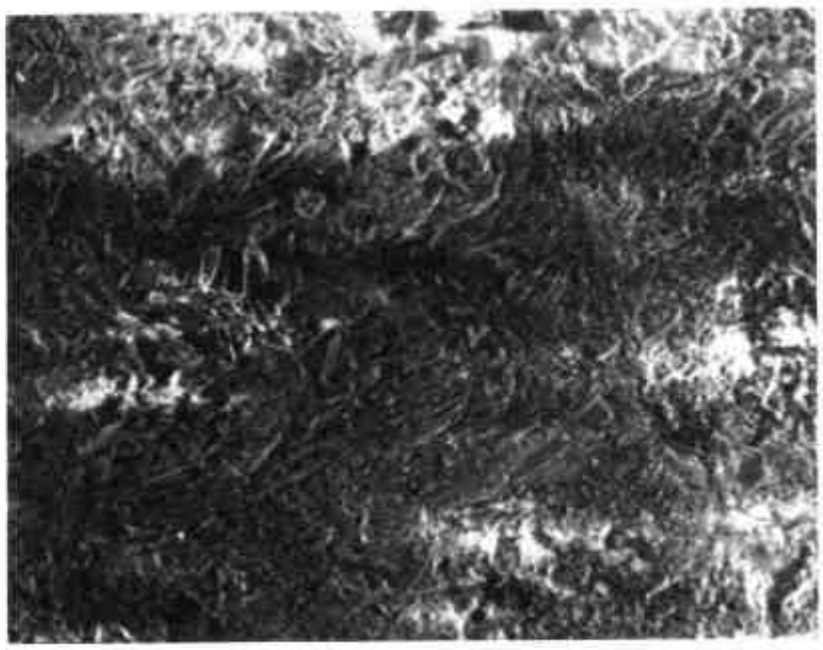


Figure 23 The scanning microscopic photo of Jin shan jade
morphology *of Tremolite crystal 1500×*

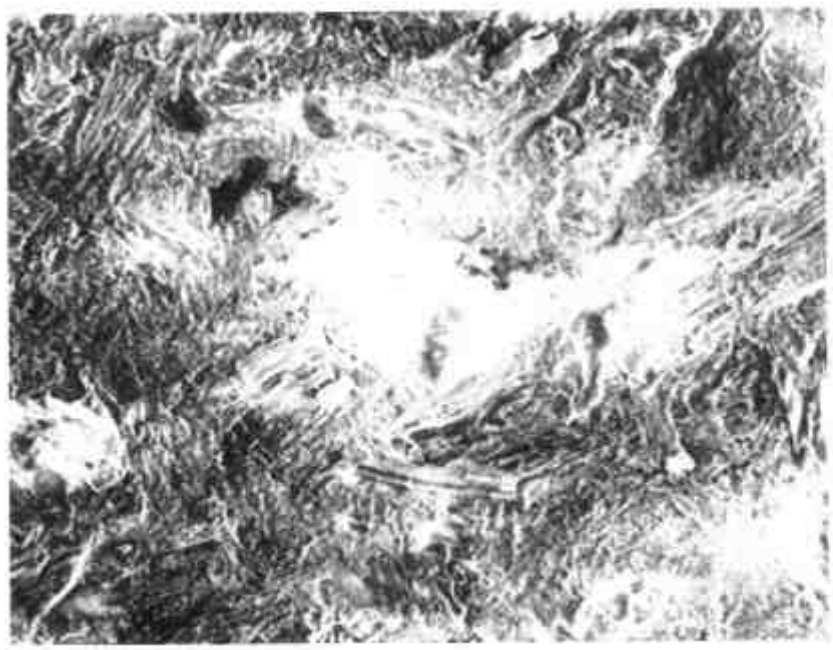


Figure 24 The scanning electronic microscopic photo of Jin-shan jade
morphology *of Tremolite crystal 1500×*



Figure 25 The transmission electronic microscopic photo of white jade
Tremolite crystal 3400×

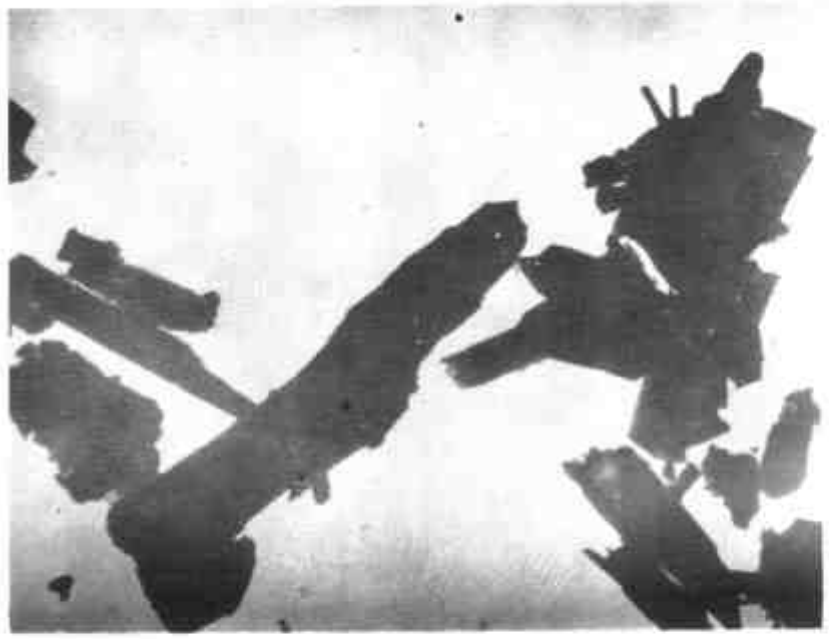


Figure 26 The transmission electronic microscopic photo of rough white jade
Tremolite crystal 3000×



Figure 27 The transmission electronic microscopic photo of grey jasper
Tremolite crystal 3000×



Figure 28 The transmission electronic microscopic photo of jasper jade
Tremolite crystal 1500×

Chart 15 The x-ray powder crystal analysis data of white jade, greyish white jade, green jade and jasper jade

	White jade		Greyish white jade		Green jade		Jasper jade	
No.	I	$\frac{d\text{Å}}{n}$	I	$\frac{d\text{Å}}{n}$	I	$\frac{d\text{Å}}{n}$	I	$\frac{d\text{Å}}{n}$
1							4	9.006
2	10	8.40	10	8.40	10	8.40	9	8.409
3	1	7.10	1	7.10	1	7.1		
4	1	5.08	1	5.08	1	5.08		
5	1	4.88	1	4.88	1	4.88	4	4.869
6	2	4.50	2	4.50	2	4.50	5	4.493
7	2	4.15	2	4.15	2	4.15		
8	2	3.86	2	3.86	2	3.86	4	3.867
9	3	(3.56)	3	(3.56)	3	(3.56)		
10	2	(3.43)	2	(3.43)	2	(3.43)		
11	3	3.37	3	3.37	3	3.37	5	3.381
12	4	3.27	4	3.27	4	3.27	4	3.264
13	10	3.12	10	3.12	10	3.12	10	3.110
14	2	3.02	2	3.02	2	3.02		
15	3	2.94	3	2.94	3	2.94	6	2.940
16	1	2.84	1	2.84	1	2.84		
17	1	2.82	1	2.82	1	2.82		
18	9	2.72	9	2.72	9	2.72	10	2.703
19	9	2.60	9	2.60	9	2.60	4	2.592
20	1	2.54	1	2.54	1	2.54	6	2.534
21	5	2.34	5	2.34	5	2.34	5	2.328
22	1	2.28	1	2.28	1	2.28		
23	1	2.22	1	2.22	1	2.22		

24	5	2.16	5	2.16	5	2.16	4	2.162
25	1	2.05	1	2.05	1	2.05		
26	5	2.02	5	2.02	5	2.02		
27	4	1.89	4	1.89	4	1.89		
28	1	1.87	1	1.87	1	1.87		
29	2	1.82	2	1.82	2	1.82		
30	2	1.753	2	1.753	2	1.753		
31	1	1.687	1	1.687	1	1.687		
32	4	1.653	4	1.653	4	1.653	6	1.647
33	1	1.615	1	1.615	1	1.615	2	1.614
34	4	1.585	4	1.585	4	1.585		
35	1	1.555	1	1.555	1	1.555		
36	2	1.535	2	1.535	2	1.535		
37	1	1.520	1	1.520	1	1.520		
38	2	1.505	2	1.505	2	1.505		
39	1	1.473	1	1.473	1	1.473		
40	1	1.455	1	1.455	1	1.455		
41	7	1.440	7	1.440	7	1.440	8	1.438
42	1	1.396	1	1.396	1	1.396		
43	3	1.365	3	1.365	3	1.365		
44	2	1.337	2	1.337	2	1.337		
45	1	1.307	1	1.307	1	1.307		
46	3	1.295	3	1.295	3	1.295		
47	2	1.277	2	1.277	2	1.277		
48	0.5	1.231	0.5	1.231	0.5	1.231		
49	3	1.201	3	1.201	3	1.201		
50	1	1.190	1	1.190	1	1.190		
51	2	1.163	2	1.163	2	1.163		
52	1	1.155	1	1.155	1	1.155		

53	2	1.125	2	1.125	2	1.125		
54	0.5	1.107	0.5	1.107	0.5	1.107		
55	3	1.082	3	1.082	3	1.082		
56	1	1.075	1	1.075	1	1.075		
57	1	1.062	1	1.062	1	1.062		
58	5	1.047	5	1.047	5	1.047		
59	1	1.037	1	1.037	1	1.037		
60	2	1.032	2	1.032	2	1.032		
61	1	1.029	1	1.029	1	1.029		
62	0.5	1.022	0.5	1.022	0.5	1.022		
63	0.5	1.012	0.5	1.012	0.5	1.012		
64	1	1.008	1	1.008	1	1.008		
65	1	1.002	1	1.002	1	1.002		
66	1	0.992	1	0.992	1	0.992		
67	1	0.987	1	0.987	1	0.987		
68	2	0.9845	2	0.9845	2	0.9845		
69	3	0.983	3	0.983	3	0.983		
70	5	0.9802	5	0.9802	5	0.9802		
71	1	0.978	1	0.978	1	0.978		

Analyst: Yu Ting-gao

3. The Characteristics of Nephrite's Infrared Spectrum

Infrared spectrum is called the "finger prints" of chemical compound. It mainly reflects the change of vibration energy level when interaction takes place between the material and infrared radiation. Various molecules have their own characterised energy level and as a result their own characteristic spectrum. Infrared spectrum is especially sensitive to the change of positive ions in minerals, and the change of composition and structure of certain mineral series, such as apatite, amphibole and serpentine. According to incomplete statistics, among the infrared spectrum chart of about 800 kinds of minerals published at present, there are not two of them that are completely the same.

We made use of the characteristics of infrared spectrum and conducted an analysis on Xinjiang's Hotan jade, Tian Shan's jasper jade and Jin-shan jade, the result is shown in figure 29-34. We can see from these figures that the peak values of Xinjiang's various types of nephrite and that of standard nephrite are close, but there is still some difference.

Brown sugar jasper, when compared to nephrite, lacks the peak at 600cm^{-1} and the peaks at 660cm^{-1} appear (figure 29).

The peak values of white jade and standard nephrite is basically the same, but the summit at 400cm^{-1} of the former is stronger (figure 30).

The peak values of greyish white jade and that of nephrite are basically the same, but the summit at 400cm^{-1} of the former is weaker (figure 31)

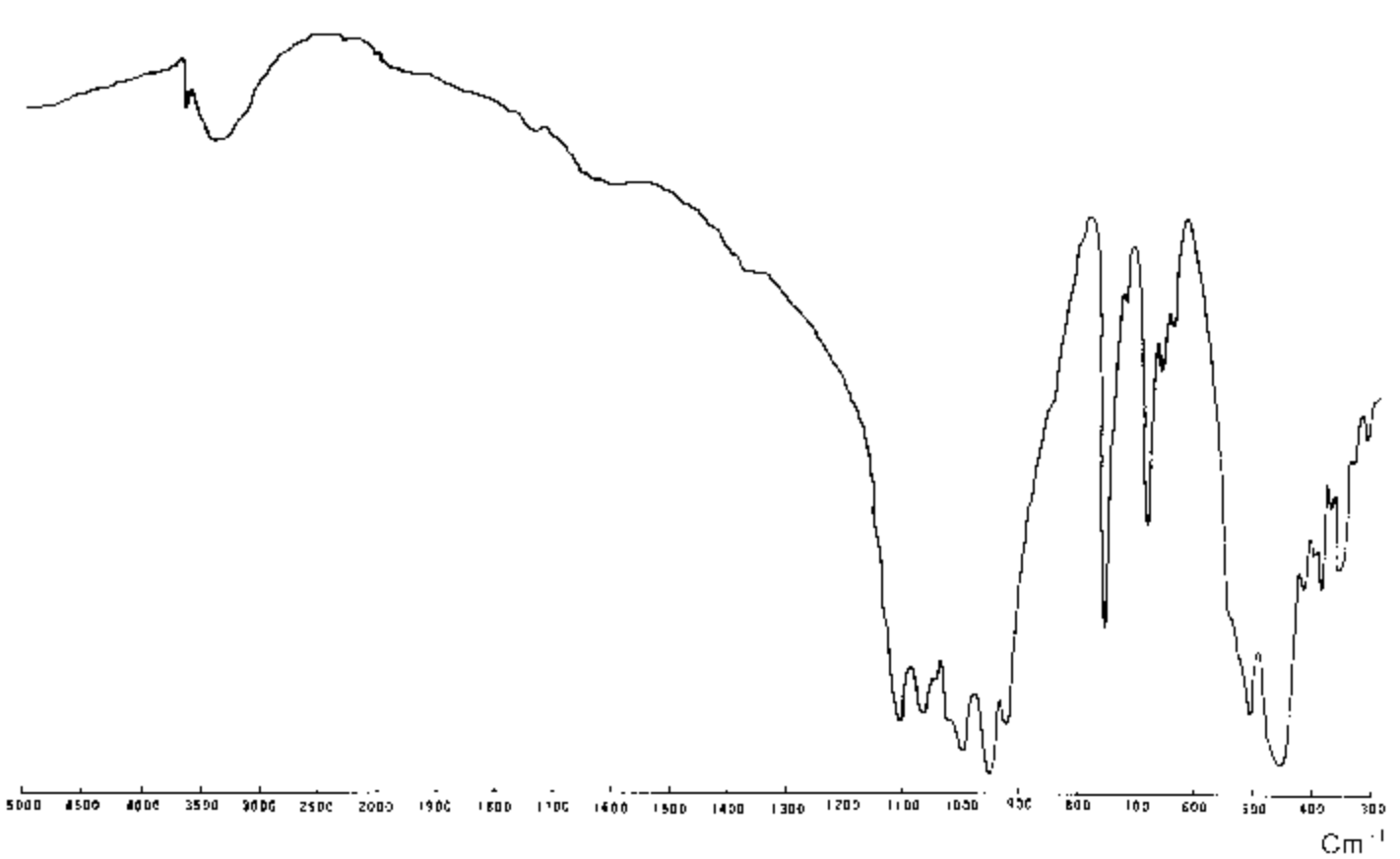


Figure 29 The infrared spectrum of brown sugar jasper

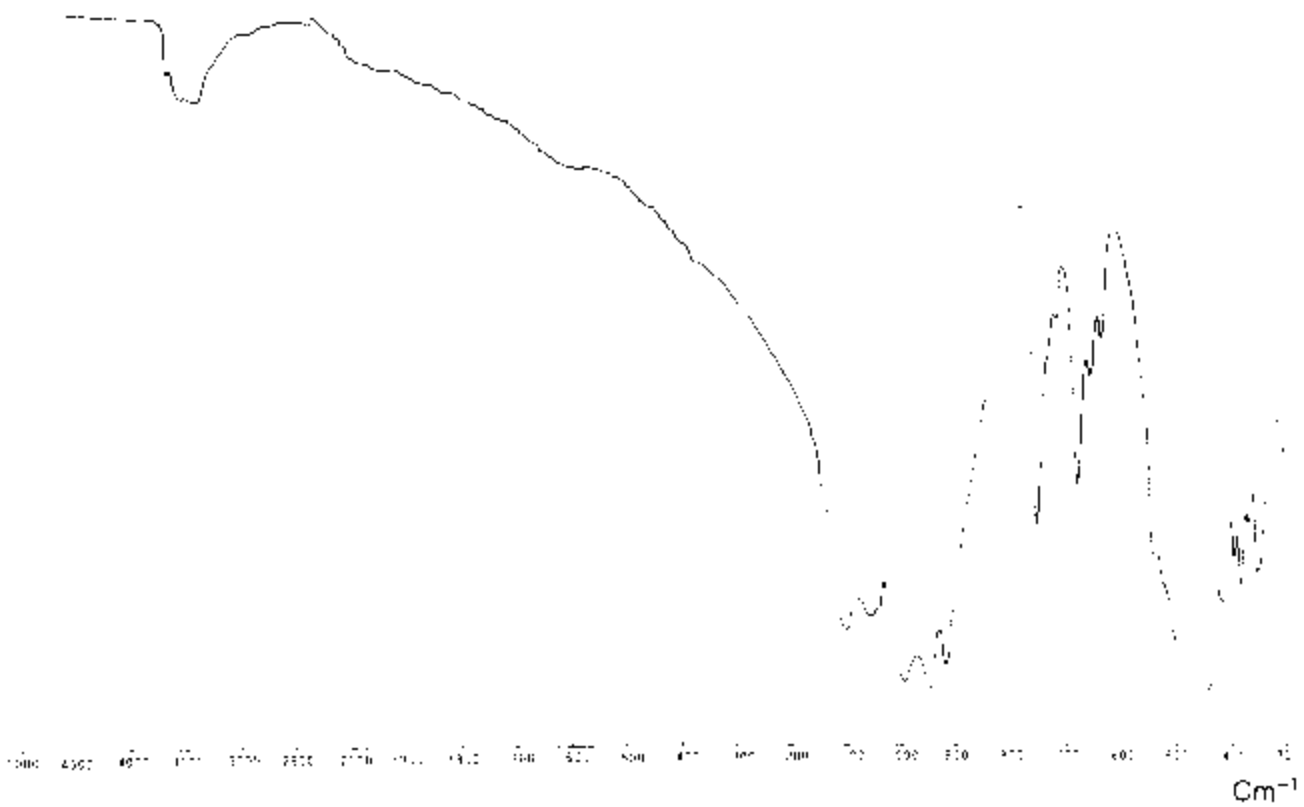


Figure 31 The infrared spectrum of greyish white jade.

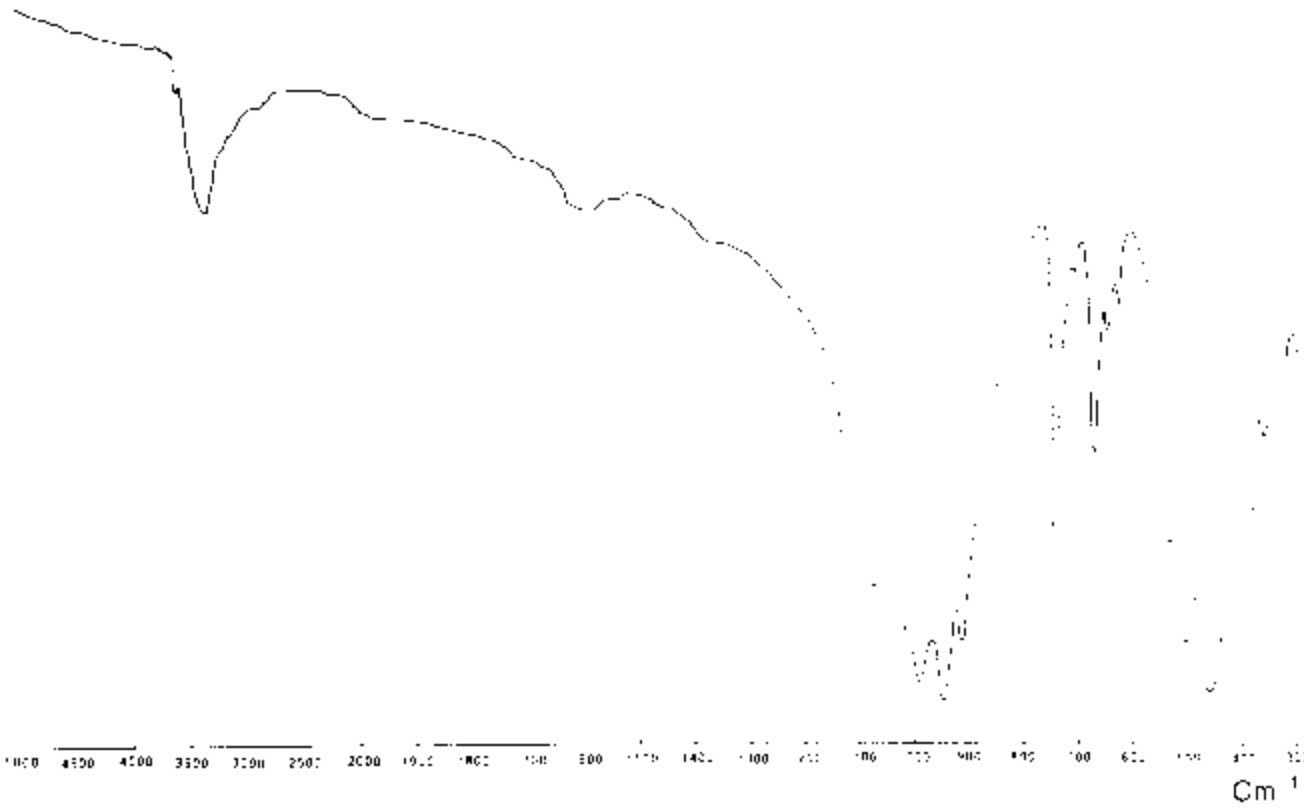


Figure 30 The infrared spectrum of white jade.

The difference between grey jasper and nephrite is weak and should peak value at 310cm^{-1}, 400cm^{-1} and 600cm^{-1} of the former is weaker. (figure 32)

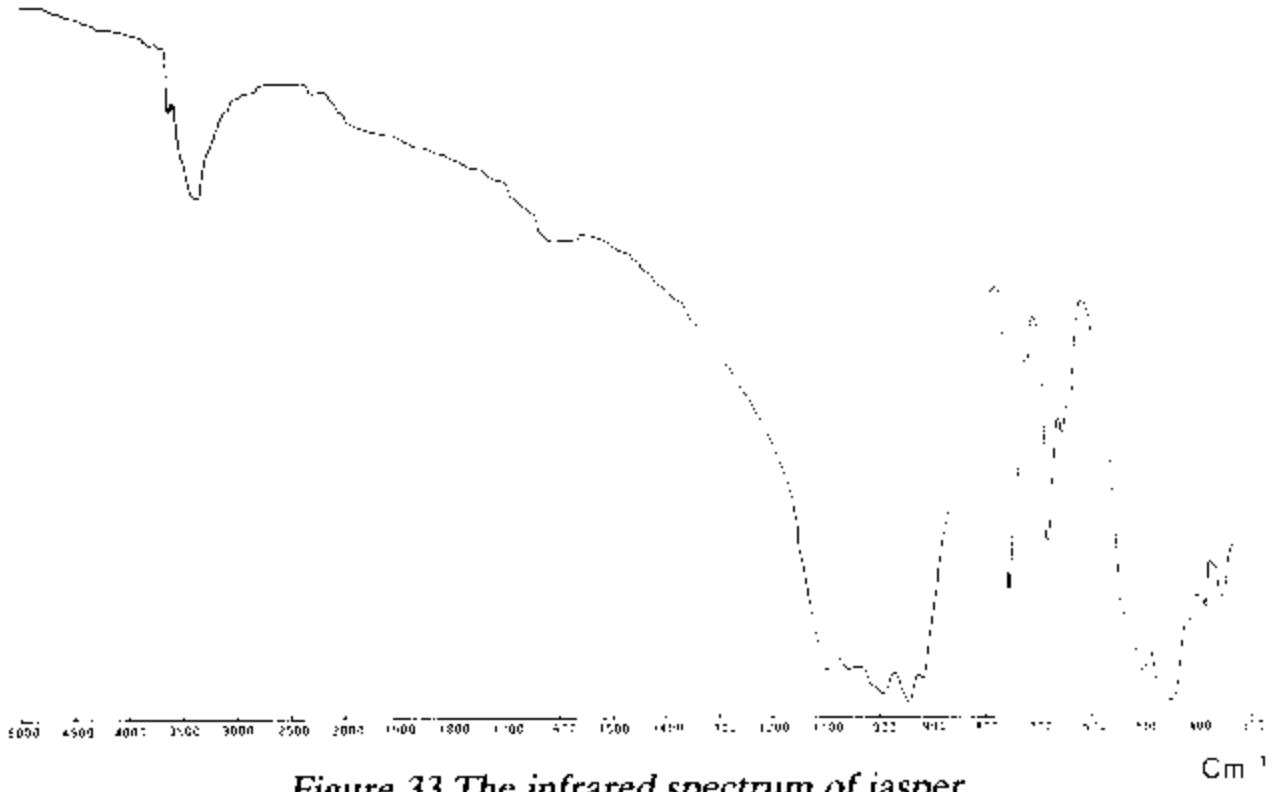


Figure 33 The infrared spectrum of jasper.

Jasper, when compared with nephrite, has the strong peak values at 3650cm^{-1}, 310cm^{-1} and 400cm^{-1} are shoulder, and are very weak. (figure 33)

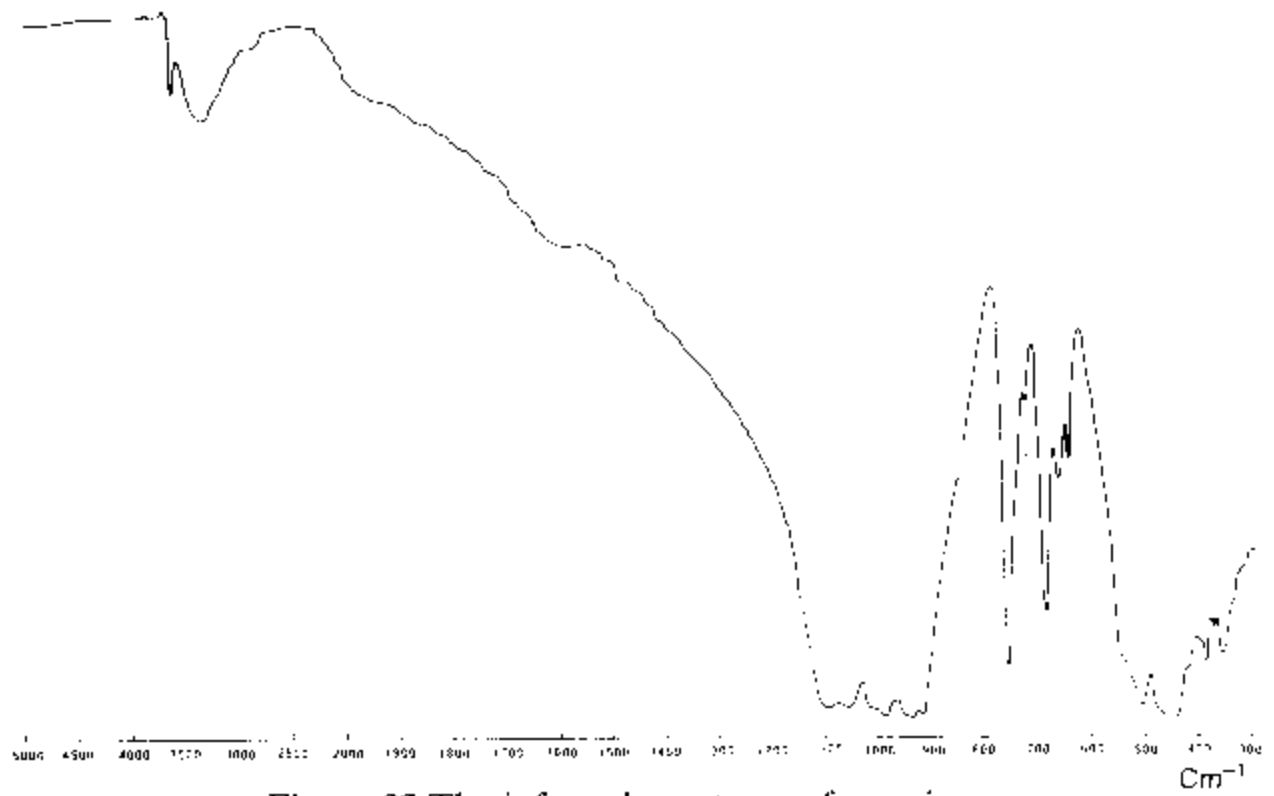


Figure 32 The infrared spectrum of grey jasper.

Jin-Shan jade lacks the summits of 310cm^{-1} and 400cm^{-1} when compared to nephrite, the summits at 350cm^{-1} and 640cm^{-1} are shoulder, and are very weak. (figure 34)

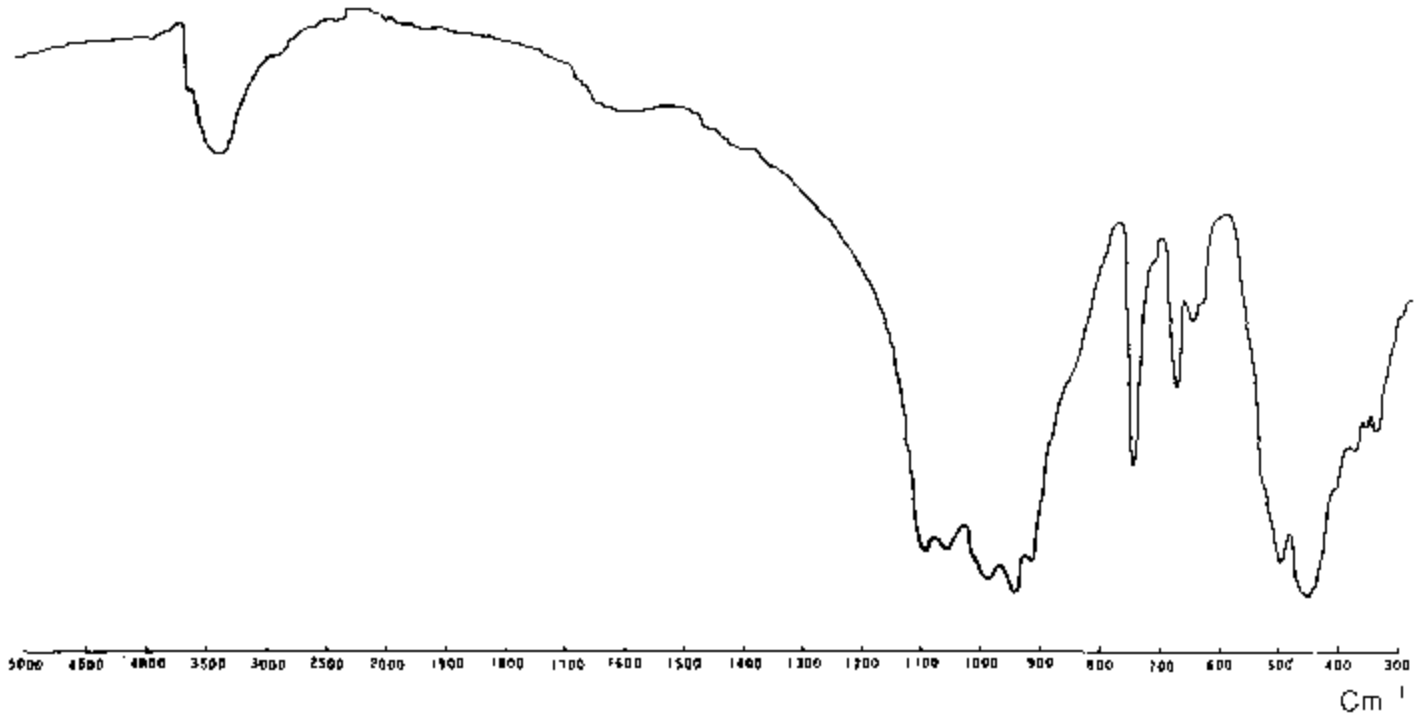


Figure 34 The infrared spectrum of Jin-Shan jade.

The infrared spectrum of the above kinds of nephrite at the low wave band has some changes, and this part is just the winding vibration of molecule key.

4. Physical Properties of Nephrite

Many physical characteristics of nephrite affect the quality of the jade. The following is the physical nature of nephrite's colour, texture, hardness, crackles, lustre, transparency, weight and tenacity.

(1) Colour

Colour is the foundation of nephrite's classification, and also one of the most important factor of its definition of quality. According to the colour, it can be divided into white jade, grey jade, yellow jade, black jade, brown jade, green jade and Jinshan jade, etc. Zhang Hong-zhiao ((Inspact of Stone)) said something about jade, "the white of snow, green of jade, yellow of wax, red of pellet and the black of ink are all of good quality." During the Ming Dynasty, Li Shi-zhen said in "Compendium of Materia Medica", Wang Yi in discussing about the colour of jade, talked about white as fat, green as green feather, yellow as steamed chestnut,red as cockscomb,black as lacquer. They are called "Yufu" (colour of jade). In ((Sketch from the Minorities)): "There are five colours of jade for Yu-tan, white jade with its colour as shortbread is the best, cool colour, glossy dark green and snow flake are inferior; yellow as

chestnut is the most precious and is called tan yellow jade, brown is secondary; for green jade, the most precious is green as indigo-blue, or with little ink stars, those with light colours are all secondary; for black jade, its colour is like lacquer; red as cockscomb is rare in the world; the green jade is green, those with rice grain shape inside are the best; lemon yellow jade's colour is light green with yellow tints; vegetable green jade with its colour in neither blue or green as leaves is the most inferior." An outline of natural resources" stated the five types of jades as white jade, grey jade, yellow jade, red jade and black jade. However, it is said that green jade with its colour green as 'grass blade and clear is of fine quality, the ones like the weeping willow leaves are of inferior quality, and this is slightly different from ((Sketch from the Minorities)). From the above description of nephrite's colour, it shows that, in order to evaluate its quality, its colour must be bright and beautiful. Nephrite's colour, in its quality evaluation, occupies a very important part. The following is the difference of various nephrite's colours:

White jade:- from white to greenish white and greyish white, the best is white. Its names are white-sheep fat, white-pear flower, ivory white, whitish-fish's belly, white-fish's bone, white-brown rice, and white-cock bone. Especially sheepfat colour jade is the highest grade material among white jades (colour photograph 28). Its characteristic looks pure and fine and seems full of water.

Grey jade:- from light green to dark green (as in colour photograph 30). Because the colour is not as lovely as white jade, the quality is lower and is rarely applied in technology.

Yellow jade:- from light yellow to golden yellow with green. Its names are wax yellow (colour photograph 42), chestnut yellow, sunflower yellow, chrysanthemum yellow, egg-yolk yellow, rice yellow and yellow-boxwood. Rare ones are steamed chestnut yellow, wax yellow. The colour of yellow jade is usually light, and have few rich ones, as a result rich colour ones are more precious. Yellow jade of high quality is not secondary to sheep greasy white jade.

Brown Sugar jade:- This jade looks like brown sugar, hence named brown sugar jade. The relation between brown sugar jade and white jade of green white jade, is gradually changed transition. The crystal of tremolite in the part of brown sugar jade is in fine long column. There is limnite distributed between long column shaped tremolite, explains that the colour of this jade owing to the contamination of oxides to tremolite forms different deep or light red in colour as in colour photograph 31.Jade in blood is the best. The thickness of brown sugar jade is not the same thin from 0.1-0.3mm, thick one may reach 20cm.Craftsman cleverly carves various craftsmanship to make use of the double colour material formed by the transitional relation between brown sugar jade and white jade, wonderfully.

Jasper jade: dim green, deep green or dark green jasper with good quality claims real colour. Deep green is better than dim green. The poorest thing is the grey colour contained in the green colour (as in photograph 44,45)

If there are black stains spots, asterisks or stripes in jasper, the quality of that falls down. Jasper jade is of the medium-grade jade. Now nephrite occurred in Tianshan belongs to jasper jade.

Black jade: between black and light black in the color; black colour which is usually distributed in spots or clouds or totally black, is described as dark clouds, light ink-black, a marten's whisker, a beauty's hair on the temples and pitch black. Among the whole raw material the degree of black could be strong or weak, deeply or lightly distributed differently. The black colour of the jade is caused by micro-flaky graphite, as in colour photograph 29.

(2) Texture

Texture means the degree of closeness of nephrite's mineral constituents structure, and that is the degree of fineness of mineral constituents crystallization. The general demand is the texture must be fine, pure, with no impurities nor "property". The main mineral of nephrite is combined by tiny tremolite crystals interwoven evenly in tiny hair shape, blanket shape or fabric shape. If nephrite contains porphyroblast or mixed with other minerals, the texture characteristics will be changed and the roughness will be shown. If impure mineral in is mixed inclusion with the jade, the obvious which is called "stone" or " stone flower" will be shown, and the unobvious is called "property". The appearance of this property is because the sizes of the impure minerals are in various shapes and perform different properties; this property is different from the structure of the jade, for example, some Kunlun Mountains' nephrites contain porphyroblast of clinozoisite; in Tian Shan green jade, there are distributions of large size tremolites in porphyroblast of chrysanthemum shape .all these affect the quality of nephrite.Below is the structural features of various nephrites. According to the observation under the polarizing microscope.

White Jade: (sheep fat-colour Jade) has pilotaxitic texture or felty texture. Its tremolite content is more than 99%, some contain a small amount of apatite, magnetite, titanite and biotite, etc. The texture of this kind of white jade is delicate and of high quality, as in figure 35.

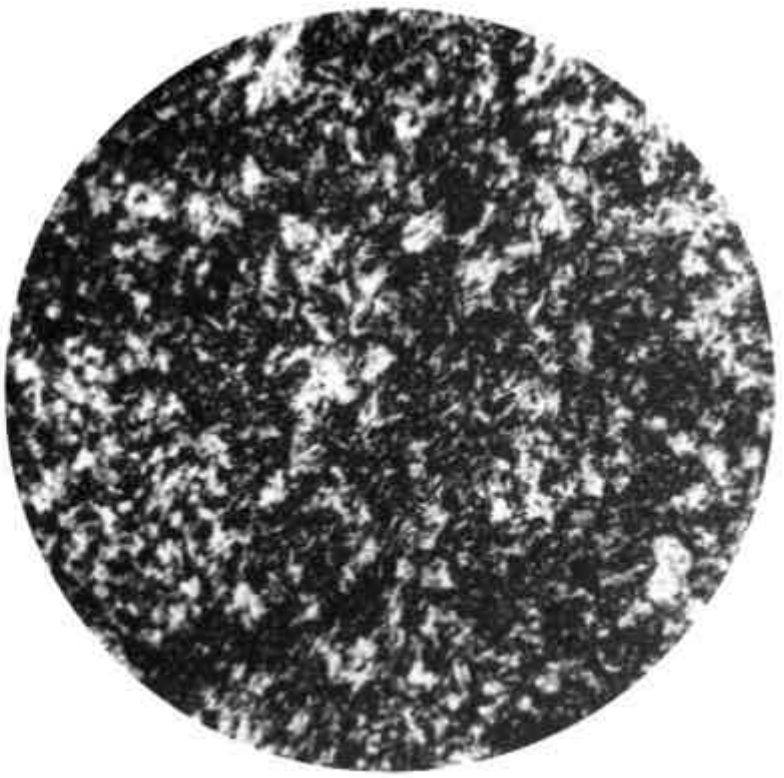


Figure 35 White Jade pilotaxitic texture of fabric metacryst crossed nicols 15×

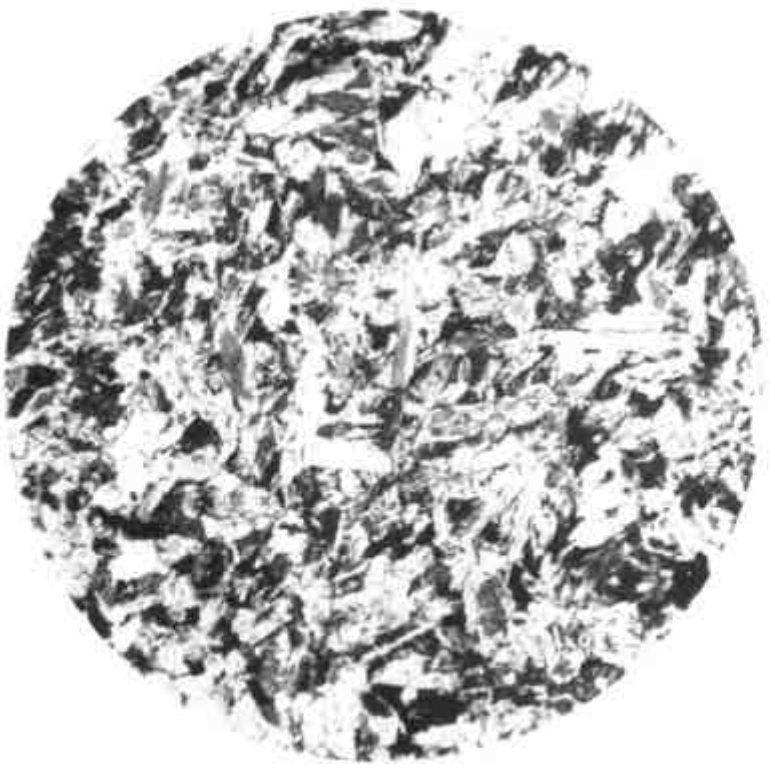


Figure 36 Rough white jade composed of long column-shaped tremolite aggregates crossed nicols 15×

Rough white jade:- composed of long column-shaped tremolite aggregates, as in figure 36. The texture is rough, and the quality is comparatively inferior. Its accompanying minerals are apatite, magnetite, titanite and biotite.

Grey jade: has metacrystal or nematoblastic texture part of it is in felty texture or radiating texture and some still have the remaining palimpsest granite crystalloblastic texture as in figure 37, and keep the palimpsest texture of the original marble rock. It thus shows that the texture of grey jade is not as delicate as white jade. In the mineral constituents of grey jade, the content of tremolite is 93-95%, other accompanying minerals are porphyroblast of clinozoisite. Light clinochlore apatite, magnetite and leucoxenife etc. Because grey jasper contains these impure minerals, it is like half-cooked rice, as in figure 38.



Figure 37 Grey jade
Fabric-shape tremolite replaces marble of granite crystalloblastic texture crossed nicols 27×

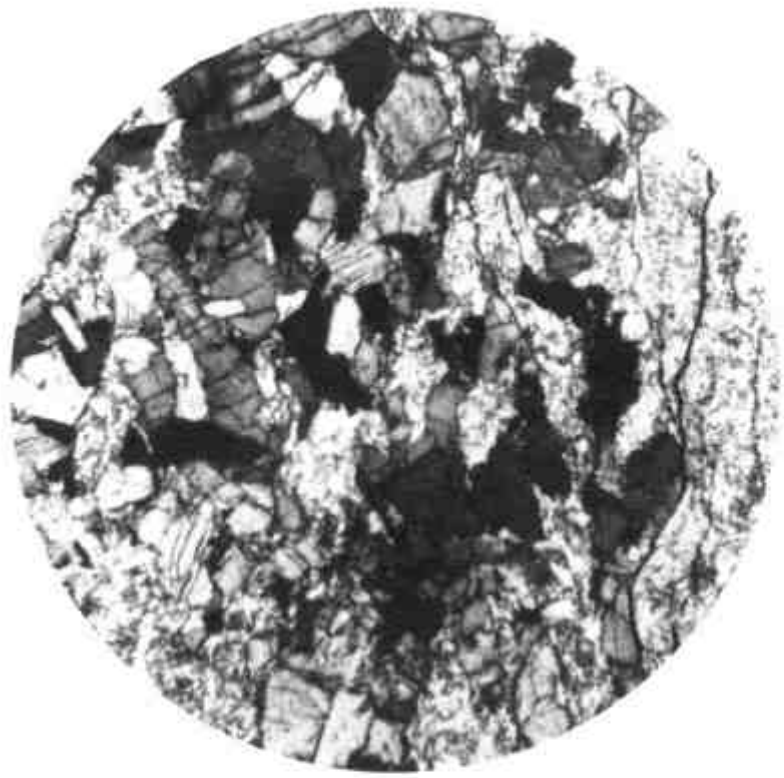


Figure 38 Grey jade with clinozoiste crossed nicols 37×

Green white jade: the interim type of white jade and grey jade, its texture is not as fine as that of white jade, but a bit better than grey white jade. Under the observation of polarizing microscope, it is found that some greyish white jade also contain palimpsest granite crystalloblastic texture, but is replaced by tremolites of larger size. Its structure is uneven and there are small veins tremolites of the later period among them. It shows that the texture of greyish white jade is the interim type, as in figure 39.



Figure 39 Greyish white jade
The remaining crystalloblastic texture crossed nicols 21×

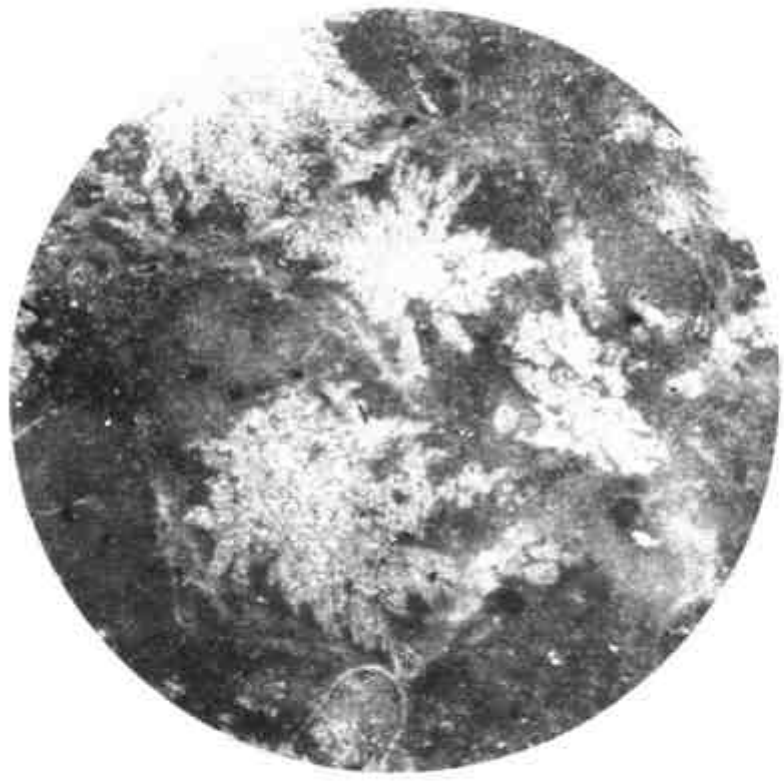


Figure 40 Jasper
chrysanthemum shape structure

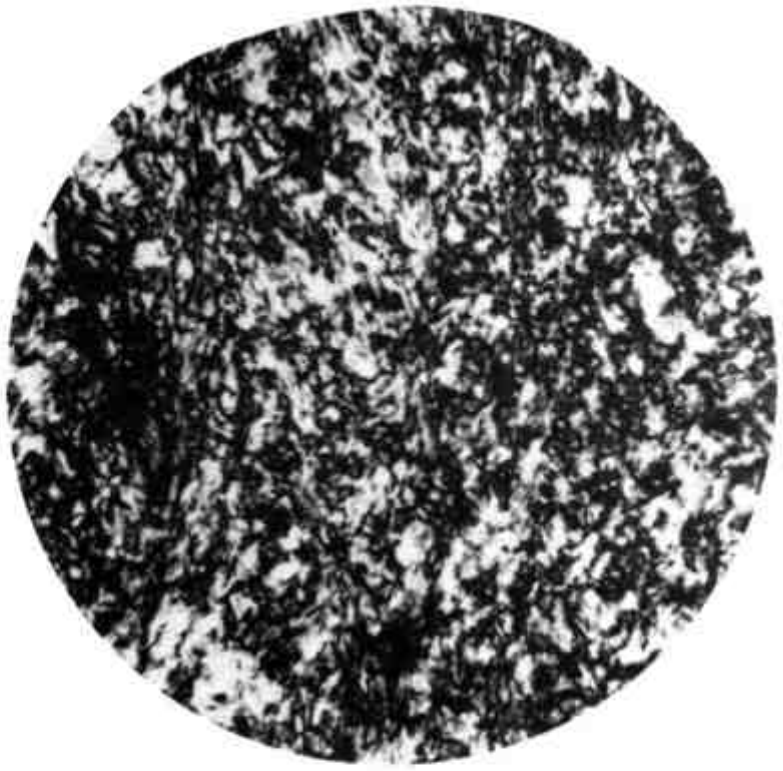


Figure 41 Jasper
Fabric column shape felty texture crossed nicols 80×

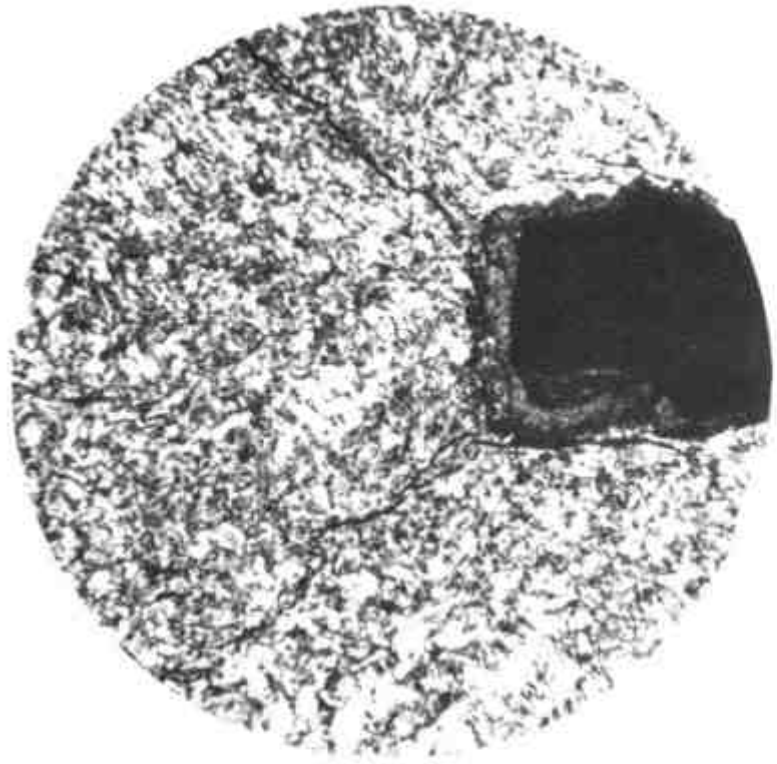


Figure 42 Jasper
Chrome spinel and uvarovite associated with tremolite in felty texture crossed nicols 127×

Jasper: nematoblastic texture or radiating taxitic texture and some have chrysanthemum shape as in figure 40. In even parts, it appears in fabric or felty texture, as in figure 41. The mineral constituent of green jade is mainly tremolite, with 96-98% of content. If there are larger crystals of tremolite, it will appear in chaotic radiative order. The accompanying minerals are chrome spinel and uvarovite, as in figure 42 uvarovite grows in the outer circle of chrome spinel, besides, there are also aggregates of milerite magnetite, chromium chlorite scattered in green jade. There are muddy leucoxene contained in felty tremolite aggregate. It shows that the texture of green jade is far behind that of white jade and is not as delicate.

(3) Crack

Crack (It is called "skeins" technologically) has important affects on the quality of jade. In ancient times, skeins were called "sickness of jade" and affected its value. It is easy to find out the crack of jade. There are deep and shallow crack and large and small ones. There are special terms for skeins, such as skeins joined together means cleavage, core skein means divergent cleavage but not as sessions; low-lying skein means fliuder cleavage.

The natural crackles of jade are slashed upon by natural force, and formed by factors like cold, heat and pressure. The intensity of the crack is closely related to the jade's tenacity and brittleness. On the whole, tenacious jade has less crackles and brittle jade has naturally more. Some microcrack of white jade can only be seen under a polarizing microscope, and have two groups of direction. These tiny crackles do not affect their technological processing. Some of the crevices of white jade's crackles are filled with muddy leucoxene and this is not a good sign. In conclusion, many nephrites, such as grey jasper and jasper jade have microcrack under a polarizing microscope. These crackles are relasted to exogenetic action after the formation of jade. The crack should be avoided as much as possible in the course of material-choosing when processed. When exploiting the jades, preventive measures should be adopted in order to protect the jade from outside force.

(4) Hardness and Tenacity

Nephrite is a wear-resisting material and has relatively stronger hardness. According to the measurement of Moss hardness white jade is 6.7, greyish white 6.5, the hardness of white jade is larger than that of greyish white jade and grey jasper. Nephrite has a great tenacity. For the measurement of compressive strength, grey jasper, in average, is 3617kg/cm^2; rough white jade 1123kg/cm^2; jasper jade an average of 4129kg/cm^2. The compressive strength of nephrite of Canada's Mount Ogden is 324-4310kg/cm^2 (4.6/61.24lb/sq. inch); USSR's is 7759kg/cm^2 (110000 lb/sq. in). They have a high numerical value, the reason has to be related to the internal texture.

(5) Lustre

Lustre is the reflectibility of nephrite to incident light. Xinjiang's nephrite has the lustre of grease, sometimes the lustre of wax and has a feeling of moisturization. Moisturization means that the lustre is soft, not too strong nor too weak and people feel a sense of comfort. The texture and hardness have a large effect on lustre. If the texture is fine, with a high hardness, the lustre must be strong, and if the texture is rough and its hardness is low, the lustre must be weak. The lustre of jade after being polished is called the degree of lustre. The higher the degree, the better the lustre performance. If the degree is high, it is called hard light and the light is strong, and if the degree is low, it is called gluey light and the

light is weak. In order to check whether the jade can be of use, it is important to see the effect after polishing: it is better to have a high degree of light and it must be even. If the degree is low and the light is weak, it is better to think over whether to make use of the jade or not. In choosing and evaluating nephrite, one must pay attention to its lustre.

(6) Transparency

Transparency is the level of permitted visibility through nephrite. When examining the transparency of nephrite, the standard is 2mm. According to this standard, Xinjiang's nephrite belongs to translucent to transparent. Whether the jade's transparency is good or not is one of the foundation in choosing jade. On the whole, if the jade's texture is delicate, with a good colour and is translucent, then it is good jade; on the contrary, it is not. In the jade-carving industry, transparency is called "shuitou" watery, or "lingdi" fairy. Good transparency can be described as fully watery, basically fairy or fairy pit, on the other hand, poor transparency, as poorly watery, un-fairy or dead pit. The former describes good jade, the latter inferior one. So transparency of jade is really important. Most of the jades have to be transparent. The shades of colour of jade have a great effect on transparency, if the colour is deep, the transparency will be lowered, light colour will improve the transparency.

(7) Weight

The numerical value of the weight of Xinjiang's nephrite, after actual determination is as follows: white jade 2.922; greyish white 2.976; green jade 3.006, black jade 2.66. We can see that the weight of white jade is comparatively lower. It is because the iron content is lower, jasper jade contains more impure iron, its weight increases accordingly. The weight of black jade is low because it contains graphite.

(8) The Lump Size and the Weight

The size of nephrite is not uniform, the largest can reach more than one metre. Besides the important demands of colour, texture, crackles and impurities of jade, the size and weight are also very important. On the whole, special grade of delicately fine white jade must be more than 8 kilogram, grade one is more than 3 kilogram, grade two 1 kilogram. The piece weight of special grade jasper jade must be more than 40 kilogram, grade one 8 kilogram, grade two more than 4 kilogram. In 1980, in the mountainous regions of the Kunlun Mountains, a lump of special grade white jade was found on the upper reaches of a certain river. It was 82cm long 80cm wide and 36cm thick, and was in square. It weighed 550 kilos. 350 kilos more than the largest piece of white jade found in the history of Hotan.

III. Classification of Nephrite

According to the difference in regions of origins, Xinjiang's nephrite is divided into two main groups: greyish white and green jade. Below is an account on the sector of their origins, their colour and technological demands.

(1) Classification of Hotan Jade

According to the sector of their origins:

(i) Whelp jade or *zieryu*: referring to the jades chosen from rivers.They are placer deposits of jades

that were eroded, washed and moved to water. Their characteristics is that the size is small and is usually oval-shaped. The surface is very smooth and on the whole the quality is fine. Some of them are found in piedmont pluvial – alluvial fan on the surface of the earth or hidden underneath among them, sheep grease jade is common.

(ii) Hill torrent: means the nephrite washed and piled up or transported by the hill wash glacial alluvion or flood not far away from the origin. The characteristics is that the size of this jade lump is big and prismatic, nevertheless the surface is quite smooth.

(iii) Native material of nephrite means original ore called Mt. jade or Baogai jade.

Division according to colour: sheep greasy jade, white jade, greyish white jade, grey jade, black jade, yellow jade and brown jade.

Division according to technological demand:

Hotan jade can be divided into several grades according to its technological demand. See chart 16 for technological demands.

Chart 16 Technological classification of Hotan jade

Variety	Grade	Standards of demands
Whelp white jade	Special	White as the fat of mutton, delicate texture, no skeins no impurities, lump weight usually more than 8 kilos.
	One	Pure white in colour, delicate texture, no skeins, no impurities, lump weight over 3 kilos.
	Two	White in colour, delicate texture, moisturised, no fragmentary skeins, no impurities, lump weight over 1 kilo.
Rough white jade	One	White in colour, delicate texture, no skeins, no impurities, lump weight over 6 kilos
	Two	Whiter lustre, delicate texture, no fragmentary skeins, no impurities, lump weight over 3 kilos.
Greyish whelp jade	One	Dark green in colour, delicate texture, no skeins, no impurities, lump weight over 10 kilos
	Two	Green in colour, delicate texture, no fragmentary skeins, no impurities, lump weight over 5 kilos

(2) Classification of Jasper Jade

Jasper jade is mainly produced in Tianshan, besides in Arjin Shan. Its technological performance is mainly decided by: the colour, the degree of fineness in texture, the skeins, the impurities, the trans-

parency and the lump size. See chart 17 for its technological classification.

Chart 17 Technological classification of jasper jade

Grade	Standards of demands
Special	Jade green in colour, delicate texture, no skeins, no impurities, lump weight over 40 kilos.
One	Deep green in colour, delicate texture, no skeins, no impurities, lump weight over 8 kilos.
Two	Green in colour, delicate texture, no skeins, no impurities, lump weight over 4 kilos.

IV. Technological Processing Requirements

From ancient times, Xinjiang's nephrite has to supply the jade-carving factories in Beijiang, Yang Zhou, Shanghai and Tianjiang. The jade-carving technology of Xinjiang is also developed and has a long history.

Because nephrite's hardness is high, it cannot be carved by general grinding machine. As a result, people in ancient times used the method of "carving stones with stones", but the speed was low. With the development of scientific technology, tools for polishing diamonds has appeared and the efficiency of jade-carving has much been raised.

Generally, the carving and polishing of jade have to go through the processes of material-choosing, design, rough shape cutting, smoothening of the surface, excavating the object itself, carving and polishing. Through the hands of jade-carving workers, handicrafts of various designs are carved, even into national treasures, such as, the green jade ring in the Tang Dynasty (unearthed in the ancient Astana Grave in Turpan, Xinjiang, the exquisitely carved Three-mouthed White Jade Lamp, unearthed in Xinjiang Uygur Autonomous Region, carved in 1098 A.D., the Jade Belt in the Ming Dynasty (see colour photograph 32), Jade Washer in the Shape of Peach in the Qing Dynasty (colour photograph 35), the Jade Cup with Twin-dragon Handles (colour photograph 33), the Twin-peach Washer made of Imperial Jade (colour photograph 34), the Jade Buckle with Twin-dragon (colour photograph 36), the Boat Sailing at the Red Cliff (colour photograph 37) and so on. Up till the Qing Dynasty, Hotan jade was exploited at a large scale during the reign of Qinlong, and large-size jade objects of various designs were carved, such as "Tu the Great Tamer of Floods". It weighed about 10,700 "jin" (colour photograph 27), and the jade material came from the mountainous region of Yearqiang Mierdai. It was carved in grey jade, which was mild, compact and in great hardness, and was 2.24 metres high and 0.96 metre wide. This carving object attractively stands as the peak does and it was carved into: lofty peaks one after another, the falls rushing down rapidly, old trees and green pinetrees everywhere, caves and streams, a large number of labourer working on the sheer precipices, striking and chiselling stone, picking sand and

grit and using simple crowbars for quarrying.

The material of this lifelike picture of labour was selected from the ancient popular legend of "Yu the Great Tamer of Floods". The design and based on the painting of "Yu the Great Tamer of Floods" drawn by a person of the Sung Dynasty, and was transported to Yang Zhou for carving in the 46th year of the reign Qinlong (1781 A.D.). In year 52 of the reign Qinlong (1787 A.D.), it was moved back to Beijing, and was placed in the Lo Shou Tang (Hall of Happiness and Longevity)of the Imperial Museum. This was up till now, the largest nephrite handicraft in our country, and was carved by thousands of craftsmen, in more than 10 years' time. Through the hands of the great craftsmen, the magnificent scene of Yu the Great harnessing the water was presented artistically on the huge jade and was handed down to the present. It was a great beginning in the history of industrial art for China's jade objects, and can be said as a rare treasure of the world. The emperor of Qinlong wrote a poem at the back of the "Yu the Great Tamer of Floods","His merit and virtue will be everlasting, Whoever sees cannot refrain from respecting Be made in painting may fade away, Be carved in jade will be everlaid."

This poem shows that Emperor Qinlong had the jade carved for "eulogizing Yu the Great of his eternal merit".

"A jade carving article Nine Elders in Huichang" used Hotan jade to carve into the scene of a jadeite mountain in Yangzhou in the 51st year of the reign Emperor Qinlong of Qing Dynasty (1786). This article carved with green and greenish grey jade is 1.45m high and 0.9m wide and weighs 830 kilogram,with a allround scene of precipice,falls, streams, and trails, the shady kiosks under the trees and bamboos, a terrace on which the cranks standing under the Wutung trees. Nine elders we wearing a long beard each bringing with seven page boys; one stands on a bridge over a stream chatting with the other; some stand in the kiosk playing chess and sipping tea; one holds a stick with a dragon head looking into the distance from the hill; one bends over a stone table playing his strings. The artical is on a brass pedestal embeded with gold lintels. The jade object symbolizes that the mountain is high, the trail reach far, and it has the scene in length and breadth. The theme of the object selected from the story in which in the 5th year of Huichang of Tang Dynasty the famous poet Bai Juyi lived in seclusing in Xiangshan in his old age, having a picnic with the nine officialdom elders. Going on an Excursion in Autumn the jade carving object, used the material of Hotan jade, adopted a painting of the court artist of Qing Dynasty with the same title "Going on an Excursion in Autumn" as its model for carving in the 31st year of the reign Emperor Qinlong in Yang Zhou and it was completed in the 35th year (1770). It cost 3,000 teals of silver and took five years to carve and polish. Being ultilized the matural green and yellow colour of the jade artistically, this jade article was carved into the autumn scene of hillwoods with full of artistic affection. Besides, there were other jade objects "The Spring Morning on a Red Terrace" and "An Elder with Cloud and Dragon Green Jade" both were big carving articles weighed several kilogram each. The Court Comprador Administration of Qing Dynasty also used Xinjiang's jade for the use and carving of seals jade books, jade pamphlet, jade musical instrument hat feather tube, snuff jar and so on. They were precious articles of jade carving craftsmanship in the history of China.

"Hotan jade" is reputedly known far and wide. The jade objects using it as the carving material are all of superb craftsmanship. They are usually praised by people and are treated as rare treasures. Thus a lot of highly-skilled craftsmen appeared. For example, there was Sun Shou who carved the imperial zeal of Qin, Cui Ning who carved the jade Guanyin of the Song Dynasty Qiu Changchuen who imparted the techniques of jade-carving extensively in the Yuan Dynasty , and in the Ming Dynasty, there was Lu Zigang who carved Zi Gang Seeing His Son Off.

Modern jade-carving technology, inheriting the foundation of traditional techniques, pays even more attention on the art of model-making and the fineness of the work. It results in the creation of a modern style and an increase of different varieties, especially about people, birds, animals and flowers, etc. For example, there were the white jade Twin-deer (colour photograph 39) and the Twin-horse made of black jade (colour photograph 38). They are lifelike and lovely. Besides, there were the "Camel and Dragon Presenting a Treasure" made of grey jasper (colour photograph 40), the Green Jade Incense Burner with 5 Loose Rings (colour photograph 41), and the Jasper Jade Bowl (colour photograph 46) the Jasper Jade Paperweight (colour photograph 47). Most of them were carved by some jade-carving factories in Xinjiang.

V. Geological Features of Nephrite's Origin

Xinjiang's nephrite deposits have two types of cause formation, one of them is distributed in the metamorphic rocks of the Pre Cambrian series from the Kunlun Mountains to the region of Arjin Mountains, those of which contain carbonatite rocks contact the intermediate acid intrusive rocks to form the metamorphic rock as nephrite called Hotan jade.The other is distributed in the north of Tian Shan, on zone of ultrabasic rock in the middle period of Variscan orogeny.

The geological conditions of Hotan jade and jasper jade's formation are difference, as a result, the quality of the jades is not the same.

1. Geological Features of the Kunlun Mountains – the Arjin Shan Nephrite's Origin

From the west of the Kunlun Mountains to the Arjin Shan, nephrite deposits are in northeast – east west – north east thread-like distribution. The primary nephrite mining areas are mostly distributed in areas above the snow line and the traffic is extremely inconvenient. In the central thriving zone of Kunlun geosyncline fold zone and on the broken blocks of the Arjin Shan, the direction of the mining areas' distribution and the structure line are identical, most of them around the large broken zone; and are produced in the metamorphic rocks of the Pre Cambrian series, on the contact zone between carbonatite and intermediate-acid intrusive body. The primary mineral of nephrite, after being eroded and washed, are brought to the surrounding rivers or the cliffs in front of the mountains. As a result, the main rivers in front of the Kunlun Mountains, such as the Karakash river, the Yuron Kash river all have placer deposits of Hotan jade and are called the "Jade River", which are the main places of mining jade before and now.

The general geological situation of nephrite deposit in Place A of the Kunlun Mountains, is complicated. There are different varieties of rock nature, the fold and broken ones are well developed. It has a strong alteration and the effect of mineralisation is not stable.

(1) Stratum

The revealed stratum in the area belongs to the Upper Palaeozoic group of the Sinian series:

(A) The marble rock section containing calcium and magnesium.

It is the important place for nephrite's mineralisation. The properties of the rock are dolomite marble rock and altered dolomite marble rock.

i. Phlogopite olivine dolomite marble rock: greyish white in colour, scales in granular like granoblastic texture. It is mainly constituted by dolomite, phlogopite and olivine. Magnesium olivine is some remaining crystal, usually replaced by serpentine, and sometimes has associated minerals like chrisotite

titanium iron ore, magnetite and clinoenstatite.

ii. Dolomite marble rock: greyish white in colour, granoblastic texture. In the crevice, there are altered minerals such as, antigorite, fabric serpentine and epidote, at a more universal distribution.

iii. Metamorphic fine grained silicarenite and olivine marble of pyritization.

iv. Olivine dolomite marble rock: greyish white, pinkish red in colour, large size granite metacrystal texture with dolomite as the main constituent, containing a small amount of antigorite, magnesium olivine and calcite. Magnesium olivine is very often replaced by serpentine, and appears in forms of remaining crystal.

v. Dolomite marble with mineralized nephrite: The colours of the rock are greyish white, pinkish red and greenish white in colour, large size granite metacrystal texture, with dolomite as the main part. This is the main nephrite layer in the mining area, usually in vein form, flat bean shape and lens shape. In some parts, Kunlun jade is associated. The quality of nephrite is not even distributed in the vertical direction, there are mainly greyish white jade and secondly white jade. Some rocks have mineralized tremolite and nephrite (felty texture of tremolite), aphanitic or fabric texture and micro-columnarmetacrystal texture.

vi. Dolomite marble:- diopside-clinozoisite marble .Greyish white coarse grain granoblastic texture and hypidiomorphic granular texture, with dolomite prodominating, small amount of olivine with serpentinization. Diopside-clinozoisite marble is the result of contact metamorphism between carbonatite and granodiorite, individually some part of olivine marble of serpentinization, mineralized tremolite marble and nephrite are in distribution.

vii. Clinozoisite diopside marble: greyish greenish in colour, granoblast texture, constituted by diopside, clinozoisite and calcite.

(B) Striped marble rock section.

It is distributed in the north of the mining area, containing graphite and pyrite, which has a small content of dolomite, and so does not has the phenomenon of the mineralize and ore body of nephrite, and has three different rock nature:

i. Graphite mineralized pyrite marble, olivine diopside marble and dimicaceous quartz schist. The graphite mineralized pyrite marble is light grey in colour,flaky metacrystal texture or palimpsest micro-granoplast texture, the content of graphite and pyrite is alway less than 5%,mainly names up of calcite.

Olivine diopside marble is light grey or blackish grey, coarse grain granoblast of hornstone texture. It mainly consists of calcite diopside, then associated with magnesium olivine magnetite, garnet dimicaceous quartz schist, grey in colour, micro-flaky or teeth form metacrystal texture mainly composed of quartz, biotite and mica.

ii. Schistose olivine marble containing graphite greyish white or blackish grey, flaky granular metacrystal texture, consisting of calcite and antigorite. The antigorite is formed by replacing olivine, which contains a little flaky graphite.

iii. Striped graphite mineralized pyrite marble. It is grey, greyish white or greyish black in colour, mequigranular granoblast texture making up of calcite diopsite and talc containing pyrite, graphite, olivine, garnet and tremolite, etc. small amount in quantity.

(2) Magmatic Rock

It is the intrusive type during the middle to later period of Variscan. Its lithological characters includes granite diorite, quartz diorite, quartz syenite, diorite, syenite-aplite and syenite. Granite diorite

has the closest relation with mineralization.

(3) Structure

The main structural lines appears in the direction of NEE – SWW. The reversed stratigraphic sequence is uniclinal structure, faults are well developed. There are six large scale faults and many small ones, most formed before the mineralization period. It is one of the conditions of control of mineralization.

(4) Features of the Ore Bodies

The nephrite deposit of district A in the Kunlun Mountains is mainly produced on the contact part of the granite diorite and marble rock containing magnesium, or dolorite marble rock.

No. I Nephrite vein

The mineral vein extends along the direction of NEE – SWW. The ratio of length and width is 3:1. There are veins of grey jasper, green white jade and white jade, and also the Kunlun jade vein, talc vein and serpentine vein. The ore body is distributed at the both sides of the serpentinization, dolomite mineralized marble. Some ore veins are around syenite, it may be related to the mineralization of potassium. The mineral vein is in the form of irregular vein and nest shape. There are grey jasper, green white jade and Kunlun jade. When grey jasper is near the intrusive rock, its colour will slightly deepen; when it is away from it, it will gradually change to white jade. Along the edge of the jade mineral vein, there is a thin layer of covering constituted by antigorite chlorite and actinolite. In some mineral veins, talc and tremolite are associated. Around some ore bodies of nephrite deposit, magnesite is associated. Some are serpentine rock (Kunlun jade) which still keeps the remaining granoblast of the original marble rock, and which are replaced by serpentine and appears to have ring-like structure. It explains that serpentine does not go through the stage of olivine and is directly handed over by dolomite.

No. II Nephrite vein

The direction of the mineral vein extends along NNE-SSW. The surrounding rock of the mineral vein is dolomite marble rock. The mineral vein mainly has green white jade, secondly green jade, or mainly has green jade, with second to it. It appears in irregular vein shape. The texture is fine but the constitution is not even. There are associated minerals like talc, tremolite,apatite and some impurity in it. On the eastern end of the mineral vein, because it is affected by the cut at the later period, the joint and schistosity are clear and well developed.

(5) The Mineral Composition and Physical Properties of the Nephrite Ore in District A of the Kunlun Mountains

The nephrite ore in district A of the Kunlun Mountains has tremolite as the main mineral constitute. Its texture is in fabric form and felty form. A small amount is in long column metacrystal texture. Very often, a lot of marble rock granoblast texture is still kept, and is handed over by fabric-shaped tremolite. It is divided into (fat colour) jade, white jade,green white jade and green jade, etc. according to the colour. In green jade and green white jade very often there is a small amount of tiny granular-like apatite (as in figure 43), clinozoiste, leucoxene chlorite and magnetite. If these impurities increase, the

quality of the jade will be affected.

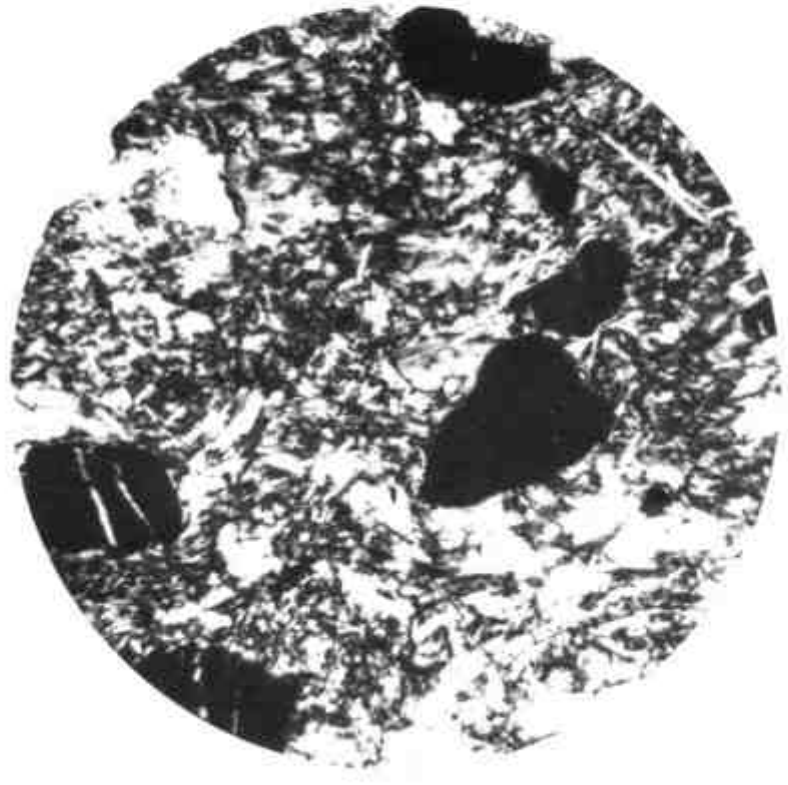


Figure 43 Green white jade containing apatite granule (black in colour) crossed nicols 100×

The physical features of nephrite is that it is slightly transparent, its hardness 6.5-6.7. The size of white jade is larger than that of green jade, weight 2.922-2.976. It has the lustre of grease, and is irregular at the cutting. The chemical composition of nephrite ore is close to the theoretical composition of tremolite, it explains that nephrite is mainly constituted of tremolite.

2. Geological Features of Tianshan Nephrite's Occurrence.

Tianshan nephrite is commonly called Jasper jade, and is produced on the zone of ultrabasic rock of the middle Period of Variscan orogeny. The architectonic position is located in Bola Hola-Ilianhabi mountain at the north part of the synclinorium extended along NW direction in lines distributed along the three faults. The ultrabasic rock belt is composed of one main rock body and several small rock bodies. The shapes of the rock bodies are in weins or lens, not big in area. The type of the rock is mainly in enstenite periodite.

The type of the rock is mainly in enstenite periodite associated with dialloge bronzite peridotite . The rock is completely in serpentinization with strong alteration. The country rocks belong to middle Devonian. The lithological character is basic-acid volcanic lava pyroclast silt stone and slate.

The low carboniferous, sand, intermediate-basic volcanic pyroclast. The nephrite ore bodies are mainly occurred in the country rocks xenolith, on top of suspended heavy body which is among the ultrabasic rock body.

The ultrabasic rock bodies which contain jasper jade are often controlled by two great press torsion faults in the north. Apart from the strong serpentinization there exist mineralized tremolite, bastite,

talc magnesite, etc. Now jasper from some area in Tianshan is described as follows.

One jasper deposits is located in an ultrabasic rock body. It is in vein, in the direction of NW290°, dip to the south with dip angle 70°. The main rock types are enstenite periodite with serpentinization, blackish green and deep green, pseudophenocryst-net form texture or net ring form block structure-schistosity developed in the margin. A lot of country rock xenolith can be seen in the ultrabasic rock bodies, making up 30%.

In certain areas, jasper jade deposit is in east-west direction. Glacial till piled up in the middle cut the pre deposit into east part and west part. The mineral body of jasper jade is in cuneiform and lens form (as in figure 44). The centre of the mineral body of jasper jade is of better quality, and the edges are worse. The centre part is of special grade and grade 1, and it gradually changes to grade 2 as it moves outward.

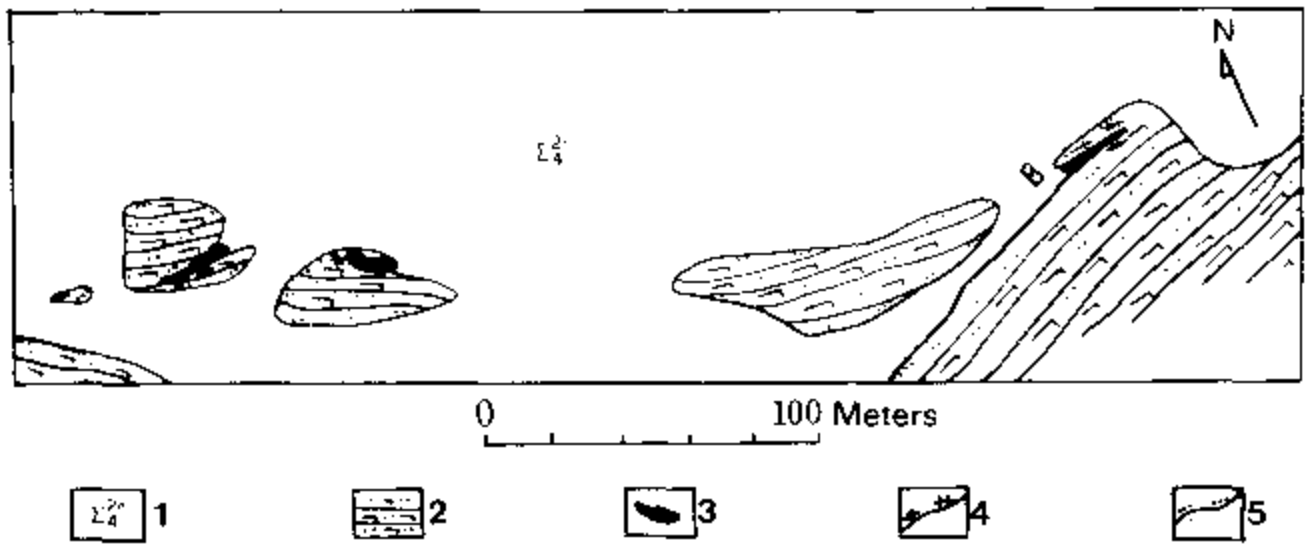


Figure 44 The distribution of the jade mineral deposits in certain areas
1. Ultrabasic rock
2. Spilite, volcanic tuff
3. The mineral body of jasper jade
4. The mineralization of chlorite and tremolite
5. Diopsidlzu

The surface of the mineral body is wrapped by a layer of "covering". Its composition is the same as the mineral body, and is mainly constituted by chlorite and tremolite. Its structure is rather coarse and does not form any nephrite deposits.

Jasper jade deposit is jade green, green and deep green in colour. It has the lustre of grease, and is slightly – translucent to opaque. Its texture is fine, tenacious and has no skein and no impurities. Its mineral constitution is mainly in microfabric form of tremolite, with light clinochlorite chlorite, chromium spinel, uvarovite, capillose, magnetic pyrite in small amount. Some can even see a small amount of leucoxene distributed among concentrated porphyritec tremolite. The structure of jade jasper ore is mainly in felty form, some are in fabric plank crystalloblastic texture and concentrated porphyritec or fabric texture and radiating taxitic texture showing that the structure is not even.

The tremolite is in fabric, needle-columnar herring-bone, felty and loosed cloth fabric texture, etc.

chlorite has pennine and lithe clinochore two sorts, chromium spinel is the special mineral in ultrabasic rock, showing that the jasper ore formed is related to ultrabasic rock, some chromium spineles are surrounded by light clinochlore and uvarovite, or replaced by aggregates. There is small amount of diopside distributed in the margin of the ore body in the jasper ore body which is altered from pyroxenolite is the product of late jasper mineralization distributed at one side serpentinite of transition or in the out of the covering diopside appears may affect the quality of the jasper ore.

The alteration of country rock of jasper ore from certain area is basic volcanic lava tuff, that often have mineralized epicote and diopside with different thickness. The ultrabasic rock bodies very often have mineralized serpentine tremolite, jasper ore happen to be distributed in mineralized tremolite serpentinite with strong alteration.

3. Geological Feature of the Nephrite's Occurrence in the Arjin Mountain Area.

In a certain area of the Arjin mountain, the nephrite ore is discovered in the place near to the contact, zone of which is between the ultrabasic rock body and the country rock. The nephrite ore is similar to Tianshan jasper, called Arjin-shan jade according to its occurrence.

Arjin shan jade is deep green in colour, fabric crystalloblastic texture, felty texture and nematoblastic texture in some part. Its mineral components are dominently composed of aggregates of fabric or nematoblastic tremolite remaining pseudo-bastite in some places as in fig. 45.

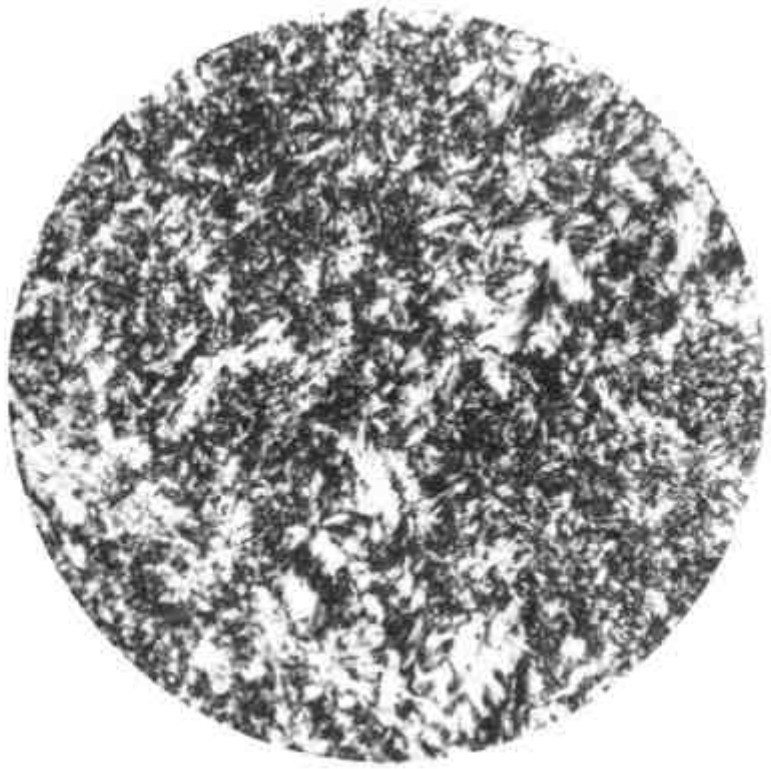


Fig. 45 Arjin-shan jade made of aggregates of nematoblastic tremolite Crossed nicols 35 ×

Ar jin-shan jade is associated with chrom spinel (chromohercynite).

The micro-granule uvarovite is distributed around the chrome spinel, very often in isometric circular shape, a few individual chrome chlorite distributed between uvarovites also smell amount of diosides

occurred in the jade.

The chemical components and its content of Arjin-shan jade as follows, SiO_2 54.65, TiO_2 0.007, Al_2O_3 1.06, Fe_2O_3 1.49, FeO 8.08, MgO 19.36, CaO 11.76, Na_2O 0.01, K_2O 0.01, MnO 0.56, P_2O_5 0.012, SO_3 0.11, $CO_2$2.78, Cr_2O_3 0.46, CoO 0.014, Ingloss 2.2. The subiron content of Arjin-shan jade is much higher than those of jasper and Hotan jade, but magnesium oxide is lower. Arjin-shan jade contains chromiun, nickel and cobalt, etc. characteristic metal element of ultrabasic rock, this means that the genesis type of Arjin shan jade could be the same as Tianshan jasper ore deposits. The gravity of Arjin-shan jade is 3.0856, higher than the jasper and Hotan jade, because of containing higher iron, to give rise to deep colour and low quality.

VI. The Ore Controlling Factor and Genesis Research of the Nephrite Ore Deposits

Xinjiang nephrite ore deposits are mainly distributed in the Kunlun, the Arjin-shan and the Tianshan mountains area. Because the nephrite ore deposits have different occurrence of geological conditions so that the grade or type of nephrite have great difference, mainly caused by the difference of the mineralization factor. The nephrite ore deposits of Kunlun and Arjin-shan Mt. belong to particular genesis type appeared in the place near to the contact zone between dolomite marble and intermediate or acid intrusive rock.

But the nephrite ore of Tian-shan and some parts of Arjin-shan Mt. belong to the other type of genesis, usually occurred in the xenolith inclosed by the ultrabasic rock or in contact zone of the rock. Now we separately discuss the controlling factor and genesis character of Xinjiang nephrite ore deposits as follows:

1. Controlling Factor and Genesis of Hotan Jade Ore Deposits.

(i) Hotan jade is the result contact metasomatic rock between dolomitic carbonitite and intermediate- acid intrusive rock (mainly granodiorite). The country rocks of nephrite ore from the Kunlun Mt. or some parts of Arjin are mostly dolomite marble or dolomitic marble, especially in the even granule dolomite which is not thick in less shape occurred in the metamorphic rock system.It is convenient for the nephrite ore to be mineralized.

Intermediate-acid intrusive rocks can be divided into diorite, quartz diorite, granodiorite, syenite, gneissic granite, etc. They appear in stock or dyke, on the whole, in fine granule or branches cross into the country rock. They are good for mineralization, as show in district A of nephrite ore deposits.

(ii) Mineralization period

The known ore localities in Kunlun and Arjin Mt. almost all appear in Precambrian strata, that is to say, the metamorphic rock system of Precambrian system is the important strata for searching nephrite ore. As oregenesis is quite near late Varisian, the mineralization period is mainly late Variscian.

(iii) Alteration of country rocks

The nephrite ores all have alteration of country rocks and occurred in certain parts, eg. district A, nephrite ore has alteration in the country rock. The first skarns alteration of contact metamorphism from granodiorite to out side scapolite-spinel eustatitite diosidite magnesium peridot marble, tremolite dolomite marble: next middle to low temperature hydrothermal replacement, give rise to the extensive clinozoisite in the diopsidite zone from granodiorite to the country rocks, but in magnesium peridot mar-

ble or tremolite dolomite marble zone, nephrite, formed tremolite and serpentine mineralized at last replaced by the low hydrothermal solution, in the place near to the nephrite ore deposits, talc, chlorite and serpentinization, sometime brucite associated may be seen . For another example , alteration of nephrite ore in certain area of Arjin Mt., epidote, zoisite and chlorite come into existence in inner contact zone, outer zone of carbonitite often there exist alteration of tremolite, serpentine, diopside, silican, talc, brucite and calcite, etc. Furthermore,there are some yellowish green fabric serpentine far from the ore body, and light green antigorite near to it, that means altered action makes zonation character.

As the genesis of nephrite ore is analysed according to the zonation property of nephrite alteration, around the contact part of the country rock in the old metamorphic rocks which contain nephrite ore, the temperature was so high during the granite intrusive process of later Variscian that it resulted in the contamination in some parts of the rocks.

During that process, the connate water of proto magma, crystalization water and other active components constituted the metamorphic hydrothermal solution moved along the zone of fracture, gave rise to metasomatism with the country rock (rich magnesium carbonitite) to form the tremolite rock, diopsidite and hornfels zone or nephrite ore deposits as in fig 46.This is an idealized model of the formation of Hotan jade ore deposit. The ore bodies are distributed along the contact zone between granodiorite and dolomitec marble.

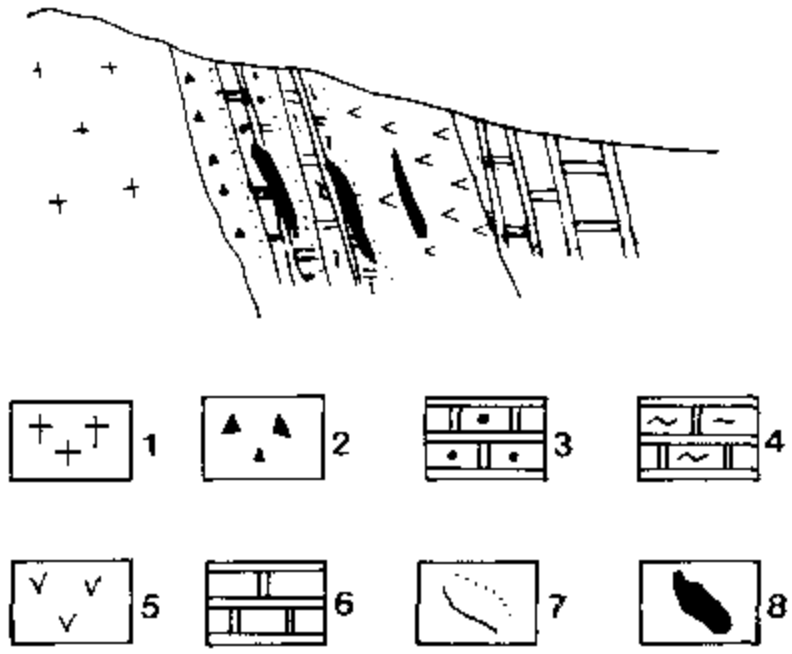


Figure 46 Showing the idealized model of the formation of Hotan jade ore deposit.
1.granodiorite 2.tremolite spinel zone 3.diopside marble hornfels zone 4.phlogopite marble zone
5. magnesium peridot zone 6.dolomite marble zone 7.boundary line between rocks 8 ore bodies

The sort of nephrite ore is related to alteration of country rocks to some extent. When the country rock of apical plate of ore bodies is dolomite marble, alteration of nephrite tremolite, jade is usually white jade and green white jade: when in the middle to become coarse grain dolomite marble, if there is porcelaneous calcite alteration, tremolite dolomite marble, there would be white jade occurred in good quality.

(iv) Controlling mineral deposits by the structure

Nephrite mineral deposits in Kunlun and Arjin Mt. is distributed in the middle upwarped district or on the fault block of zone of fold, for example,the middle upwarped district of Kunlun geocynclinal zone of fold, fault block of Arjin Mt. ore bodies often found in the zone of fracture, faulted zone or the near place on the up wall of abyssal fault. It is generally considered that the expanded spaces in the open system are advantageous to mineralization eg. nephrite ore of district A.

2. The Ore Controlling and Genesis of Jasper Ore Deposits

i. Mineralized rock and altered action. The country rocks of jasper are ultrabasic rocks. There are two types: one is harzburgite and peridotite, the other is pyroxenite. The xenolith of spilite and tuff can be found in the country rock among the ultrabasic rocks. The distribution of jasper often appears in the contact zone or the nearplace of the country rock xenolith among the ultrabasic rocks. The formation of jasper ore is, on the whole, considered that ultrabasic rock is undergone the alteration of serpentine and tremolite then become nephrite ore, very often appeared remaining chrome spinel or altered spinel in this type of nephrite, also skialith of pseudo bastite or felty tremolite replaced chrysotile in the low grade nephrite or semi-nephrite rock, showing that nephrite keeps the structure of the original rock.

The surface of the jasper ore body has alteration of chlorite tremolite (from tens of cm to several m wide).

The strong altered chlorite tremolite zone is very close to the nephrite ore body under the stress. with strong schistosity, tens of cm wide, inside out occurs a weak chlorite altered zone. It is gradually changed between zones.

ii. Mineralization period

It is known that the ore produced in the ultrabasic rocks of Variscian contains the xenolith of splite and tuff of Devonian-Carboniferous period. Jasper formation of mineralization period should be the same in Variscian.

iii. Controlling ore deposits by the structure

Jasper ore deposits are both in lens shape or sphenoid on plane section or cross section fixed into the contact zone or crevasse, showing that the mineralization related to the structure crevasse.

If deeply fixed, both sides of wall were country rock, then the quality of ore would be better. Generally considered that the quality is better under closed down environment. According to the information analyses of geological character of jasper ore deposits, it is considered that the formation of jasper ore deposits in certain area of Tian-shan Mt is related to direction of SN or south to north compression between Gondwanaland and Angaraland. Under this compression, gave rise to the zone of fold in Tian-shan Mt. suffered compression force between Tarim geoanticline and Junggar depression. There is a flat end at north upward part of Tarim geoanticline pointing to the north to a jasper ore deposits zone in certain area, and to be going to bend up to the north. After the intrusion of ultrabasic rock, two groups of shear cracks with obtuse angle under compressional action created advantageous space for the formation of jasper ore deposits. There is no ore body on the plane parts of contact zone between ultrabasic rocks and strata, showing that even centripetal press does not form jasper ore deposits.

Shear fracture of obtuse angle may only be occurred in the short time. The action of compression stress immediately concentrated in the breach area formed by the zone of shear fracture. Heat capacity produced by the friction of fracture gave rise to high temperature, tremolite replace serpentine to form felty nephrite. Lens shapes ore deposits were formed in zone of shear fracture on both plane section and cross section, quality is better in the centre of ore bodies, gradually poor inside out.

iv. The transition of chemical elements

After ultrabasic rock suffered the metamorphic serpentine itself, and under the better condition of structure,nephrite could be formed until the transition of chemical elements must be companied too.The average comparison of chemical elements between serpentine and nephrite as in chart 18.

Chart 18. Comparison of chemical elements between serpentine and nephrite

Oxides	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	NiO	H_2O^+
Serpentine	38.84	0.06	1.24	4.76	3.60	0.10	37.47	0.37	0.10	0.06	0.02	0.42	0.23	12.73
Nephrite	53.14	0.07	2.79	0.73	4.53	0.08	22.75	10.53	0.20	0.05	0.07	0.30	0.17	4.79

From chart 18, when serpentine became nephrite it gave Si, Ca, gave Mg OH, up, Fe, and then changed from Fe^{+3} to Fe^{+2}. That is to say it changed from oxide environment to reduce one, from low density to high density. This is a further evolution process of metamorphism. It is just the mineralized process of nephrite. Because the hydrothermal metassomatism does not exist obviously around the ore bodies, several meter wide mineralization of light clinochlore tremolite appeared in the country rock, ore body contact the country rock directly showing that the total active transition of elements is not too much.

The genesis of jasper ore deposit is in the process of regional metamorphism. The other idea considered that it is the result of metasomatism of late magmatism. It means that the jasper mineralization started after the serpentinition ended before tremolite, may be the genesis of hydrothermal action.

Section Two Kunlun Jade and Serpentine Jade

I. Kunlun Jade

1. General Introduction

Kunlun jade has got its name because it is produced in the Kunlun Mountains. It belongs to the same type with Liaoning's Xiuyan jade.

The discovery and utilisation of Kunlun jade in Xinjiang has just taken place in recent years. In the historical document "Kunlun's production of jade", mainly referred to Xinjiang's nephrite, Hotan jade. Kunlun jade is constituted of serpentine. On the whole, the texture is comparatively delicate and soft, and the colour appears in light green or yellowish green and can be made into jade objects of various kinds.

2. Physical and Chemical Properties of Kunlun Jade

Kunlun jade is mainly constituted of chrysotile and lizardite, thus it is also called serpentine jade. If the colour is pure white, then it is called new pit white jade. Kunlun jade is mainly in dark green,

there are also other colours like light green, light yellow, grey and white. The colours are usually from light to dark, the darkness is like luxuriant rape leaves, having other associated colours with green such as browish red, yellowish red, yellow, green, white and black as shown in colour photograph 48 and 49. The jade appears in translucent to slightly transparent form and has greasy luster. Its hardness is 4.5 to 4.8, its tenacity is less than nephrite and fracture is irregular. Its specific gravity is 2.603.

Kunlun jade appears in nematoblastic texture and nemato-lepidoblastic texture under the polarizing microscope, as shown in colour [photograph] 47 and 48 in which the content is mainly chrysotile, secondly is lizardite and antigorite and it also contains a small amount of leuchtenbergite, magnetite and trace amount of ilmenite. The size of chrysotile is 0.1-0.2mm, without fixed directional arrangement of grain. The distribution of lizardite is not even. Magnetite appears in needle form, and is 0.2mm long, 0.02mm wide. The talc appears in small scaly shape and is distributed in forms of aggregate. Kunlun jade is usually penetrated by small carbonate veins of the later period.

Because of the difference in geological setting of Kunlun jade, there is a divergence in its content of mineral composition . There are more lizardite in some parts and more chrysotile in others, and there are also some with more antigorate. Thus, its colour is not the same in different positions.

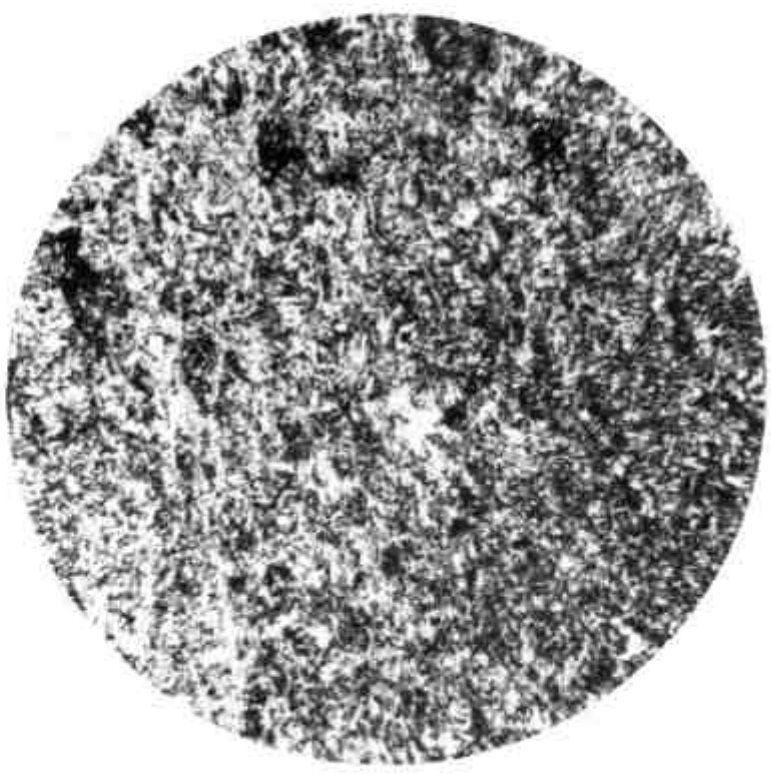


Figure 47 Kunlun jade
Fibrous nematoblastic texture, constituted mainly of chrysotile and lizardite, containing also some antigorite and magnetite.
Crossed nicols 35 ×

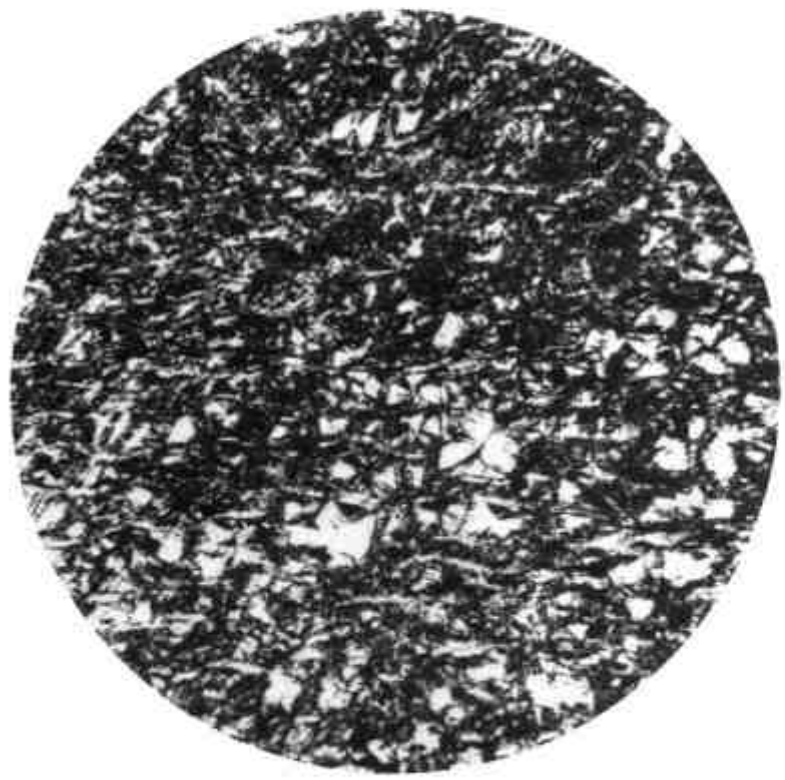


Figure 48 Kunlun jade
Nemuto-lepidoblastic texture, mainly constituted of lizardite and chrysotile. Lizardite appears in sand-bell texture.
Crossed nicols 35 ×

Under transmission electron microscopic observation, serpentine retains its crystallization behavior, and shows the characteristics of layer structure, as shown in figure 49.



Figure 49 Characteristics of Kunlun jade's texture enlarged to 3000 ×

The chemical composition of Kunlun jade is listed in table 19. Its composition does not change greatly and is close to that of Xiuyan jade.

Table 19 Chemical composition of Kunlun jade

Oxides / Examples	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	TiO_2	SO_3	CO_2	H_2O^+	P_2O_5	ign. loss	F	total
1	45.00	0.46	0.18	.58	42.00	.43	0.00	0.01	0.01	0.00	0.06	0.43	10.36				99.52
2	44.66	0.45	1.26	.18	41.06	0.71	0.08	0.00	0.026	0.00				0.80	11.70	0.28	100.21
3	43.63	0.98	0.82	.62	40.28	0.24	0.06	0.20	0.03	0.08	0.20			0.04	12.85		100.03

3. Technological Processing Requirements

Kunlun jade of fine quality has a delicate structure, with no crackles or impurities. The colour is bright or in pure white. It is divided into three grades according to its technological requirements:

Grade 1: Clear smart colours like deep green, white, red and yellowish green, slight skeins and a little bit of impurities, transparent, lump weight over 40 kilos.

Grade 2: Clear smart colours like deep green, green, red and yellowish green, slight skeins and a little bit of impurities, transparent, lump weight over 15 kilos.

Grade 3: Green, transparent, with no fragmentary skeins, a little bit of impurities, lump weight over 10 kilos.

In conclusion, Kunlun jade belongs to low-grade jade, and has a wide usage. It is a kind of indispensable jade material.

4. Geological Features of Kunlun Jade Occurrence

Kunlun jade in Xinjiang is mainly distributed in the Kunlun Mountains and the Arjin Mountains. It occurs in the contact zone between dolomite marble or dolomitic marble and the intermediate intrusive rocks in the vein form. The Kunlun jade mineral veins of certain areas are taken as an example to explain its geological features (as shown in figure 50).

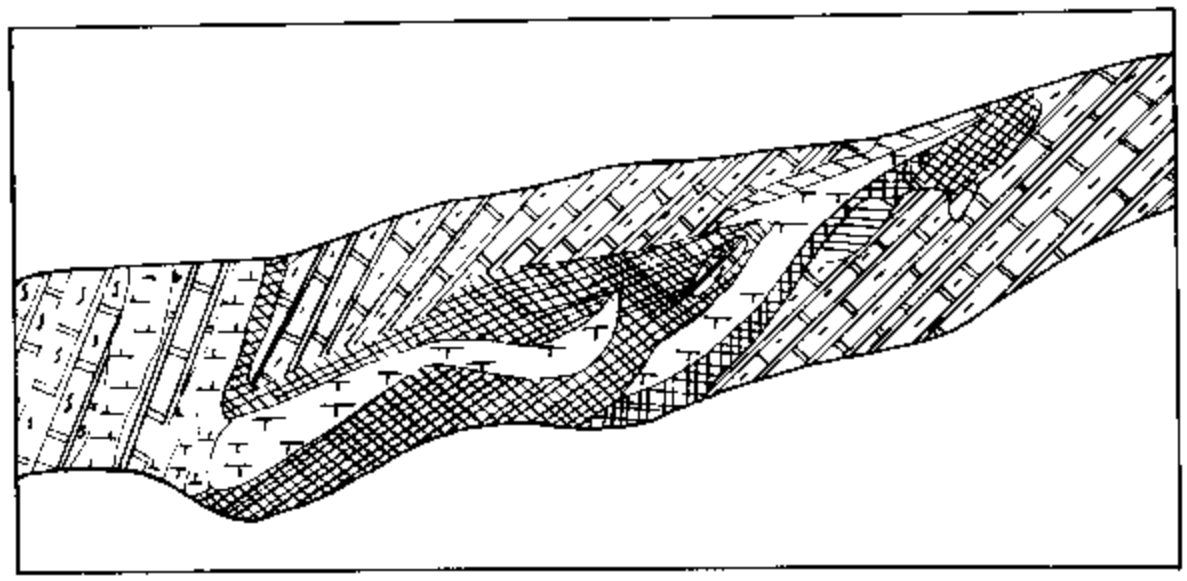


Figure 50 Geological features of Kun lun jade occurrence

1. Dolomite marble 2. Diorite 3. Strong serpentinized marble 4. Greyish white jade 5. Syenite 6. Kunlun jade 7. White jade

The Kunlun jade vein is distributed on the southern margin of the nephrite vein A. It is relatively regular and has obvious contact boundary with white jade and is in direct contact relation with greyish white jade, but boundary is not obvious, with a gradually transitional trend. In the Kunlun jade ore body, there are strongly serpentinized elliptical marble xenoliths which have obvious boundaries with the former. The reason that the marble was not completely replaced is that its content of magnesium is low. The xenoliths were only serpentinized and no Kunlun jade formed. Syenite and diorite has the phenomenon of interweaving. Kunlun jade has contact relationship with these two kinds of intrusive rocks. The wall rocks which are most favourable for mineralization are chiefly dolomite marble and secondly dolomitic marble.

II. Serpentine Jade

1. General Introduction

The serpentine jade is a new variety of jade defined in 1981. It is mainly constituted of serpentine and chlorite. The colour is "Pea green". It was named according to the name and colour of the constituting minerals.

2. Physical and Chemical Properties of Serpentine Jade

Serpentine jade has a delicate structure. Its colour is pea green, partially uneven, having black spots and yellow bands. It has conchoidal fracture, hardness 5, specific gravity 2.52. It is smooth and has greasy luster. It shows foliated or cryptocrystalline texture under polarizing microscope.

The mineral constituents are mainly lizardite, secondly chrysotile and chlorite, containing also a small amount of carbonate minerals polluted by limonites. Individual pyrites scatters like stars. The size of pyrite is 0.001mm. The appearance of pyrite does not affect the quality of the jade, on the contrary, it beautifies the jade and improves the quality.

The analytic results of the chemical composition of serpentine jade and trace element spectrum are as follows:

Chemical composition	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	MnO	SO_3	ign-loss
Content(%)	36.00	9.52	1.21	3.54	0.60	35.73	0.04	0.06	0.18	0.10	13.08

3. Technological Processing Requirements of Serpentine Jade

Serpentine jade is a newly defined variety. Soon after its discovery, it was well-received by jade-carving workers. Its technological requirements are basically the same as that of Xiuyan jade or Kunlun jade.

4. Geological Features of Serpentine Jade Occurrence

The serpentine jade in vein form penetrates into the fractures of ultrabasic rock body. The width of the vein is about dozens of cm, the length depends on the scale of the fractures of ultrabasic rock. On the whole, it is longer along the edge of ultrabasic rock. the wide of the vein may have a great change.

Section Three Lilac Purple Jade

1. General Introduction

Lilac Purple jade is a new variety defined in recent years. There were just a few years' time from the definition of the variety to the trial carving of the stone and sale of the products.

Lilac purple jade (colour photograph 53) has won the praise of gem appraisers, antique dealers and craftsmen for its magnificent colour, purple lilac delicate and fine texture and smoothness. It was named because its colour looks like the purple colour of lilac.

No matter carved into the facets of jewellery, or personages, or other handiworks, lilac purple jade has a better effect. As a result, emphasis is put on the search for this kind of jade. It was first found in

northern Xinjiang. In recent years, new occurrences of lilac purple jade were found in eastern Xinjiang.

II. Physical and Chemical Properties

Lilac purple jade is the technological name of the jade. Mineralogically and petrologically, it is a mono-mineral aggregate of lepidolite. The rock is mainly constituted of micritic scaly lepidolite and a small amount of quartz and albite (as shown in figure 51). The size of the scales are usually about 0.04mm^2. They are all formed in the late stage of metasomatism of sodium-lithium granite pegmatite.



Figure 51 Scaly crystals of lilac purple jade
Crossed nicols 35×

Lepidolite belongs to the monoclinic system. The crystals are usually foliated, scaly or fine scaly in shape. For those with larger crystals, pseudohexagonal prisms formed by foliated crystals can be observed. The colours are generally rose, lilac purple, light purplish grey and grey, with colourless streaks. It has the pearly luster and silky luster. The mono-crystal is transparent, the microcrystal aggregates are from semi-transparent to opaque. Cleavage:{001}, complete cleavage, hardness: 3.22-3.67. Brittleness: elasticity.

Optical Property: Lilac purple jade appears in pink, grey or colourless on thin slices. The cleavages are extremely complete. It appears to be cuneiform foliated and slaty in shape. The aggregate often with flexurally wavy extinction, generally approximately parallel-axial extinction , and with biaxial negative character; 2V is 15-20°, sometimes 10-20°. Index of refraction Ng=1.5685, Nm=1.5655, Np=1.5520, Ng – Np=0.0165, r>γ, Ng∧C=4°.

Chemical Property: The powder of lilac purple jade can be dissolved in dilute hydrolic acid and white

silica gel precipitates can be separated out. The chemical analysis result of lilac purple jade is shown in table 20.

Table 20 Chemical composition of lilac purple jade

Chemical composition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	MgO	K_2O	Na_2O	Li_2O	Rb_2O	Cs_2O	F	H_2O^+	H_2O^-	Total
Content (%)	48.58	31.24	0.32	0.03	0.05	0.13	10.47	0.52	2.99	0.88	0.14	0.06	3.14	0.57	99.12

According to the spectrum analysis of lilac purple jade, the trace elements contained are as follows: Ga, Be, Cu, Fe, Bi, Ba, Sr, Zr, Nb, Zn, Mo, V, Co, Ni and Ta.

III. Technological Processing Requirements

Lilac purple jade is a newly defined variety of jade and its technological properties in certain aspects are not yet known, but many of its properties can be defined.

The technological requirements of lilac purple jade is mainly on its colour, secondly, its size, degree of compactness and skeins. If all these requirements are met, its utilisation value and grade can be raised.

Generally, lilac purple jade appears in a fine compact piece of crystal, and has a relatively low hardness. It has elasticity and good polishing properties. Products made of lilac purple jade, no matter which a plain crown facet is or a complicated handicraft, both have a smooth finish.

Lilac purple jade has the soft and pleasant colour of purple lilac, thus its products, especially those in large size, produce a sense of beauty. For example, lilac purple jade "Drunk Li Bai" (colour photograph 50), the lilac purple jade "Incense burner with elephant design" (colour photograph 51) and the lilac purple jade "Pagoda incense burner" (colour photograph 52).

Because lilac purple jade can be processed into crown facets, necklace beads or carved into other products, the requirement on its size is not too limited. It can be $1cm^3$, and there is no limit for the large ones, of course, the larger the better. The largest piece found in the granite pegmatite in northern Xinjiang has a diameter of 50cm. It is really a rare material.

According to trial carving, lilac purple jade can be carved into necklace beads, crown facets, personages, landscapes, vases, pagoda stoves, pagodas and buildings. It is a jade of medium grade and its products are well received in the markets.

IV. Geological Features of Lilac Purple Jade Occurrence

So far, lilac purple jade in areas of Xinjiang are just found in granite pegmatite. It mainly occurs in the swelled part in the centre of the sodium-lithium-type pegmatite which has undergone strong replacement. It constitutes aggregates with tiny slices of albite, and appears in form of nests. Sometime, it forms nest-like aggregates with spodumene and caesium silicate. These aggregates are of different sizes. Lepidolite is the product of the later stage replacement of granite pegmatite. It is formed during the later

period of granite pegmatite. but has difference in order of time specifically. According to field observation and indoor study, lepidolite can be divided into two stages of crystallization.

1. Early-stage Lepidolite is foliated, scaly and isometrically scaly in shape (wavy extinction with tiny flexure).The folium are usually larger than 1mm, bigger ones can reach 3cm. The early stage lepidolate is the main constituent albite – lepidolite aggregate. It replaced muscovite and albite in rims. And sometimes penedrated into quartz. Purple lepidolite replaces firstly the edge of muscovite, and then develops gradually to the centre. The strong replacement resulted in the disappearance of cuscovite, and scaly lepidolite filled the covity of the albite crystal. Sometimes, on the same piece of specimen, the phenomenon of albite being replaced by muscovite, which is again replaced by lepidolites, can be seen. Lepidolite at this stage usually forms aggregates with pollueite and spodumene. Lepidolite at this stage cannot be used as jade material.

2. Late – stage Lepidolite in fine foliated scaly form. That cannot be clearly observed by human eyes. The colour lilac purple can still be seen the pearl lustre under the sun. In field, it is distinguished from other minerals by its colour. Tiny scaly lepidolite in forms of small veins penetrates the space between the lepidolite, spodumene and quartz-albite. In the cleavages of albite and fractures of polychromatic tourmaline are filled with lepidolite of this stage. Lepidolite of this stage can be technologically used as lilac purple jade if they attain a certain size with good "water" and little or no "wool" lines.

Here we take an example of granite pegmatite in certain region of Tianshan Mountains and explain the geological features of lilac purple jade occurrence.

The granite pegmatite is found in the Hercynian muscovite granite which occurs the Hercynian fold zone in Tianshan Mts region. The country rocks of the granite pegmatite are siliceous schist and gabbro. The western part of muscovite granite appears in band shape, and extends gradually eastward to become network veins, or "isolated island" and to form a hilly terrair. The rock is white to greyish white and is even-grained – coarse-grained in texture, partially fine-grained and poikilitic texture. The mineral constituents are mainly albite, quartz and muscovite, and secondly garnet. The accessory mineral is magnetite. It has massive structure and appears in creamy to greyish white in colour after weathering.

There is no obvious boundary between the granite pegmatite veins and granite. Both appear in gradually transitional contact. The granite pegmatite vein is some hundred metres long, the some dozens of metres wide. Trend of the vein is 340°, dip angle: 70°. The vein is divided into the following zones from inside to outside according to their mineral composition and texture. (Figure 52)

(1) Central quartz zone (quartz core). The quartz is white to smoky in colour, translucent to slightly transparent, in piece form. The zone is situated in the centre part of pegmatite.

(2) The zone containing lumps of spondumene, feldspar and quartz is distributed on the two sides of the central quartz zone. The colour of spodumene is complicated, from white, pink to cherry red. It becomes pink after weathering and is easily broken. It appears in large crystals. The spondumene at top of the zone is branched or radial in occurrence, while at bottom it appears bands or lumps. The quartz lumps are white, and semi-translucent. It is more difficult to distinguish spodumene from feldspar, but spodumene has obvious striation. In that zone, that are also a small amount of beryl and niobium – tantalum iron ore. The albitization replacement at the southern side is strong with spodumene enrichment. In the northern part , mineralisation took place only locally.

(3) The graphic and transformed graphic zone. It is composed of microcline, plagioclase, quartz

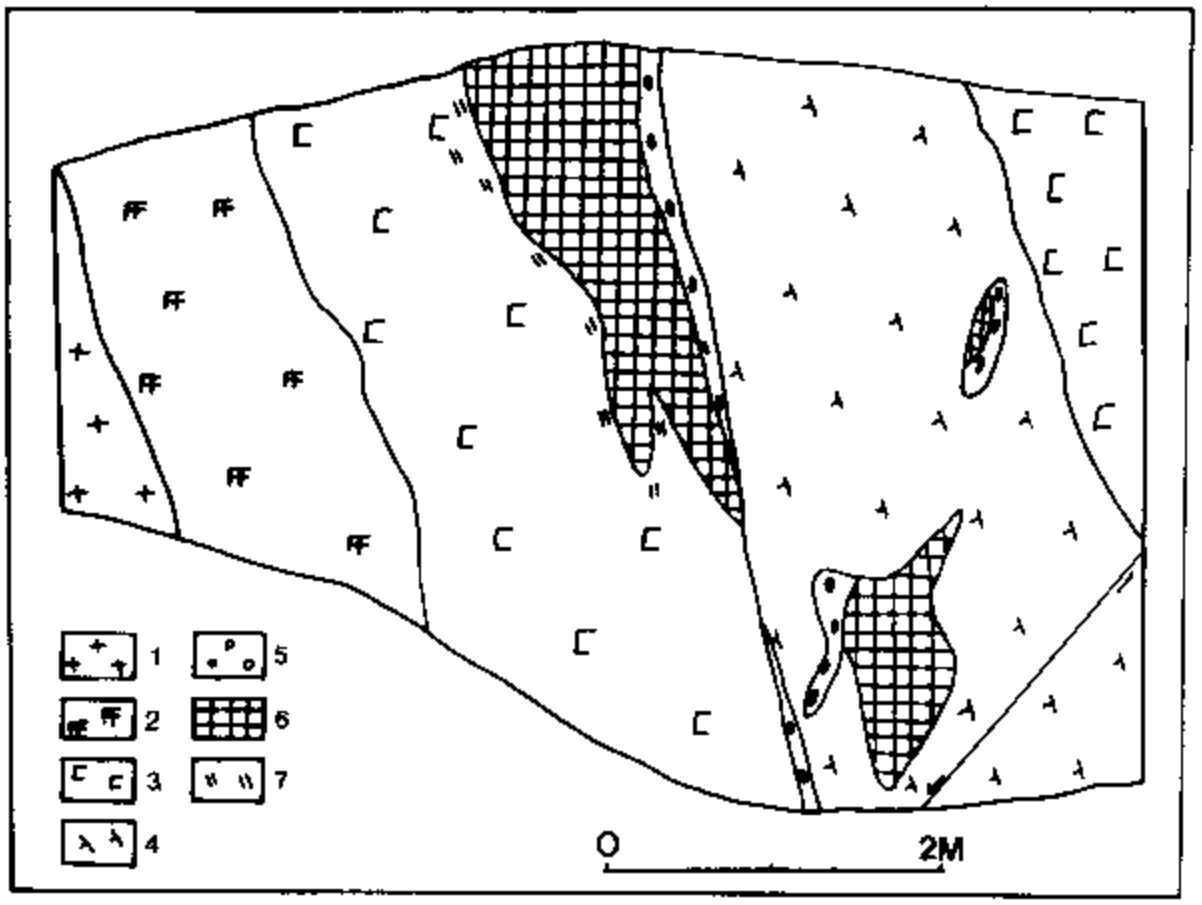


Figure 52 A sketch map of lilac purple jade ore body

1. Muscovite granite 2. Graphic, transformed graphic pegmatite 3. Medium to coarse granular pegmatite 4. Quartz feldspar zone 5. Quartz zone 6. Ore body of lilac purple jade 7. Muscovite

and muscovite. Quartz is regularly or irregularly distributed in feldspar, constituting the graphic and transformed graphic texture. The microcline is pinkish red – greyish white and has a perfect crystal shape.

(4) Aggregate of mica and quartz – It is distributed which are located in the swollen parts at the east and west end of the pegmatite vein. In the spodumene and quartz-feldspar zone and the quartz core, it appears in a small lens shape, irregular shape or lump form. It is constituted mainly of fine scaly lepidolite, and albite and quartz are found locally. The lepidolite is light purple and greyish white in colour.

Lilac purple jade occurrences are found in all the pegmatite distributed areas in the Altai and Tianshan Mts regions in Xinjiang. This kind of deposits may also be found in other regions.

Section Four Rock Crystal

I. General Introduction

Rock crystal is a kind of well crystalized quartz crystal that is colourless and transparent. It is called crystal stone technologically and was called water jade in ancient times.

Rock crystal and quartz have long been used by people. In our country, early as the Stone Age, people used them as tools. Among the unearthed objects in the past dynasties , there were always objects of rock crystal. For example, there were the raw rock crystal objects in the Shang Dynasty; the rock crystal varieties of different colours in the Zhou Dynasty; the peeling tools in crushed quartz sheet of the New Stone Age among the cultural relics displayed in Xinjiang's Historical Museum; the white quartz sheets among the stone core and stone sheets of the New Stone Age unearthed in the Luobuzhuoer and the human-shaped mark carved in colourless and transparent rock crystal of the Northern and Southern Dynasties that was unearthed in Bachu, Xinjiang, and which was oval-shaped, with its size 3x3x3cm^3.

Xinjiang has a various of rock crystal variety. The deposits of rock crystal in Xinjiang are in many genesises and are widespread.

II. Physical and Chemical Properties

1. Physical Property

Rock crystal has the lustre of glass and grease, and it is colourless and transparent. If there are impure elements contained different colours will be shown. Its hardness is 7, its specific gravity 2.651-2.66. It has conchoidal fracture and no cleavage. It has a relatively high elasticity, thus will not be easily crushed when mechanical vibration (elastic vibration) is conducted on piezoelectric quartz sheet. It has a relatively high compressive strength, and can resist 28,000 kilos of pressure in each cm^2 of the area along the parallel optic axis. Rock crystal is easy to be crushed into powder form. Its ability of heat conduction is poor, its melting point is 1713°C. It has a small expansion coefficient and light-penetrating ability and can pass through ultraviolet ray and infrared ray. Its transparency is affected by colour, inclusions, fractures and air cell and thus has a difference. Rock crystal with a good transparency is valuable material of optical instrument.

2. Chemical Property

The chemical property of rock crystal is stable. Its main component is SiO_2; which is dissolvable in hydrofluoric acid and not dissolvable in water. However, under the condition of high temperature with high pressure, or medium temperature with high pressure, rock crystal can be dissolved in alkaline solution.

III. Classification of Rock Crystal

1. Classification according to Colour

Rock crystal can be classified into smoky quartz – dull greyish brown, blackish brown; amethyst-

purple (as colour photograph 61,62); rock crystal – tea crystal – tea-like brown (colour photograph 55); citrine-yellow; rose quartz – rose (colour photograph 54); greasy quartz-milky white.

2. Classification according to Inclusion

(1) Rock crystal containing solid inclusion

Solid inclusion is the solid material inside the crystal, which was wrapped during crystallisation. Its composition is usually closely related to the compositions of the solution, the geode and the rockforming minerals. In ancient times, people thought that rock crystals containing inclusion were rare treasures and they were doubly praised. Nowadays, rock crystals containing grotesque inclusions are still considered to be a precious material for jade-carving, and a fine quality raw material for masterly craftsmen to perform their superb skills.

Solid inclusions can be divided into two types: one type is fragmental (the inclusions has irregular shapes); and the other is minerals having definite facets and forms. Inclusions for different minerals may have various patterns, such as fabric form, wadding form and granular forms.

The occurrences of solid inclusions in the crystal may be in layers or scattered form, and they are usually inclusions in scattered form. Hair crystal and bristle crystal can be subdivided from the forms of the solid inclusions (colour photograph 57,58, 59).Hair crystal is in long and thin shape (like hair), that of bristle crystal is shorter and thicker (like horse's mane). Common solid inclusions are minerals like chlorite, rutile, pyrite, mica, tourmaline, kyanite, tremolite, actinolite and garnet.

(2) Rock crystal containing fluid inclusion

Gas inclusion and liquid inclusion appear together very often. The main gases are HF, HCl, H_2S, CO_2 and volatile and BF_3.Gas inclusion is common in crystals, especially in its root. Compact gas inclusions usually appears as "fog" thus lowering the crystal's transparency.

Liquid inclusion is formed mainly under comparative fast speed of crystal growth. There are parent solution, water solution, carbonic acid solution or other mixed solutions. Crystals with liquid inclusions are called water-bag crystals. Those with large water bags are precious ones.

Crystals with solid, liquid and gas inclusions have different locations and forms, and often affect the application and economical value of rock crystal.

Rock crystals in Xinjiang can be divided into: amethyst, citrine, rose crystal, smoky crystal, hair crystal,bristle crystal and water-bag crystals, among them are more precious because they are rare. Bright-coloured amethysts are gems of medium grade, on the whole, rock crystals are medium-grade jade.

Besides classifications according to colour and inclusion, rock crystals can also be classified according to their shape. Special-shaped ones can be decorative stones, such as rock crystal druse (colour photograph 56).

IV. Technological Processing Requirements

Rock crystals should be spotless and clear, with no impurities, good transparency, that is, they must be bright and shining. Those that are black and dull are of low quality and do not satisfy the

requirement. It was recorded in: "Those that are white as ice, bright and crystal clear, with no flaws or impurities are good." Thus, to distinguish and appraise the quality of rock crystal must start from the texture, colour, transparency, size, forms of inclusion and their distribution characteristics.

1. Texture: If refers mainly to the degree of crystallization. The crystals that have no impurities and a pure texture are high transparent and have a good quality. If the crystal contains opaque materials, then the form of the material contained must be defined. One kind of it is floccule white or the same colour with the crystal. It affects the transparency, thus rock crystals containing white inclusion are of worse quality. The other kind is that different colour minerals are contained in the transparent crystal and manifest a magnificent sight. This kind of rock crystal is precious. If the inclusion is red and needle-like, the value of the crystal will exceed common crystals.

2. Colour: Rock crystals have various kinds of colour. The colour of the crystal must be rich, like that of amethyst, citrine and smoky crystal. If it is of one single colour, and it lightens gradually from the top to the bottom, then attention must be paid to the increase of the opaque floccules. With the increase of the floccules, the value of the crystal will decrease.

3. Size: It refers to the part of crystal that can be utilised. For amethyst and citrine, if the size is sufficient to carve a crown facet, it can be utilised. Tea crystal and smoky crystal can be made into glasses, so the standard is to be able to cut glasses from it. As for the carving of jade, the size should be larger.

4.Crackle:the nature of rock crystal is brittle. It cracks easily because of the effect of various natural forces in nature. Crackles can be penetrating and un-penetrating, both of them affect the application of the crystal.

5. Technological Grading of Amethyst and Rose Quartz

Amethyst:

Grade 1: the colour of purple grapes, bright, transparent, no impurities, no crackles, lump weight over 0.5kg.

Grade 2: the colour of purple grapes, bright, transparent, no impurities or little impurities, a little bit crackles, lump weight over 1 kg.

Rose quartz:

Grade 1: deep rose red in colour, transparent, no impurities, no crackles, lump weight over 12 kilos.

Grade 2: rose red in colour, transparent, little impurities, lump weight over 8 kilos.

V. Geological Features of Rock Crystal Occurrence

Xinjiang has abundant rock crystal resources, and various types of deposits. The identified ones are granite-pegmatite type and hydrothermal quartz vein type. They are described as follows:

1. The Rock Crystal Deposits of Granite Pegmatite Type, Xinjiang

(1) General Geology

The strata belongs to lower Carboniferous System. The intrusions are mainly medium-acid lava, forming diorites, porphyritic-like biotite granite, potash granites, and etc. Dikes include: crystal-producing pegmatite, quartz vein, oplitic vein, oplite-granitic vein and aplite-dioritic vein, and etc.

(2) Geology of Deposits

i. The shape, scale and occurrence for granite pegmatite

The pegmatites in this area are quite concentrated in distribution. Their crystal producing veins shapes are isometric-like, irregular tube, veins and lens. The former two are the main crystal producing veins in this area, the latter two have a poor zoning and generally do not contain crystals.

The scale of pegmatite is generally not large, and the occurrence is usually chaotic and varys widely not having any regular pattern.

ii. Texture zoning and mineral associations of pegmatites

The pegmatite veins of this area have several sets of texture and differentiated well. They can be divided into the following zones from exterior to interior:

A. The marginal zone of pegmatite

B. Graphic – texture pegmatite zone

This zone has two alnatives, graphic texture zone and metasomatic graphic texture pegmatite zone. On the whole, graphic – texture veins are better crystal producing veins.

C. Feldspar quartz mass zone

Inside the zone are mainly small masses of quartz and feldspar. The size of the mineral is generally 10-30cm , individuals can reach 0.5-1 metre. The main minerals are microcline, quartz, there are also perthite, albite, and also biotite and muscovite. The accessory minerals are zircon, apatite, rutile, magnetite, ilmenite and anatase.

D. Feldspar mass zone

This zone is less developed than feldspar quartz mass zone. Its width varies according to the size of the vein. It is usually located in the centre part of the vein. The quartz cores is surrounded mainly by microcline and perthite besides are biotite, tourmaline and fluorite. Accessory minerals are zircon, apatite and sphene.

This zone locally forms the feldspar geode, in which there are complete crystals of feldspar. Associated with it is rock crystal, but it is of comparatively small amount.

E. The quartz core

Quartzes within the quartz core are white, greyish white and milky white in colour. The edges and the lower part of the core changes to greyish white and smoky grey in colour. The core is mainly block texture, otherwise, prism-like texture. It is translucent, has grease – glass luster. There are usually some remained geode at the lower part of the quartz nucleus.

The above zones of pegmatite in this area, except those outside the quartz core, – are not well-developed in horizontal direction, but those that are along the vertical direction developed quite well (as in figure 53).

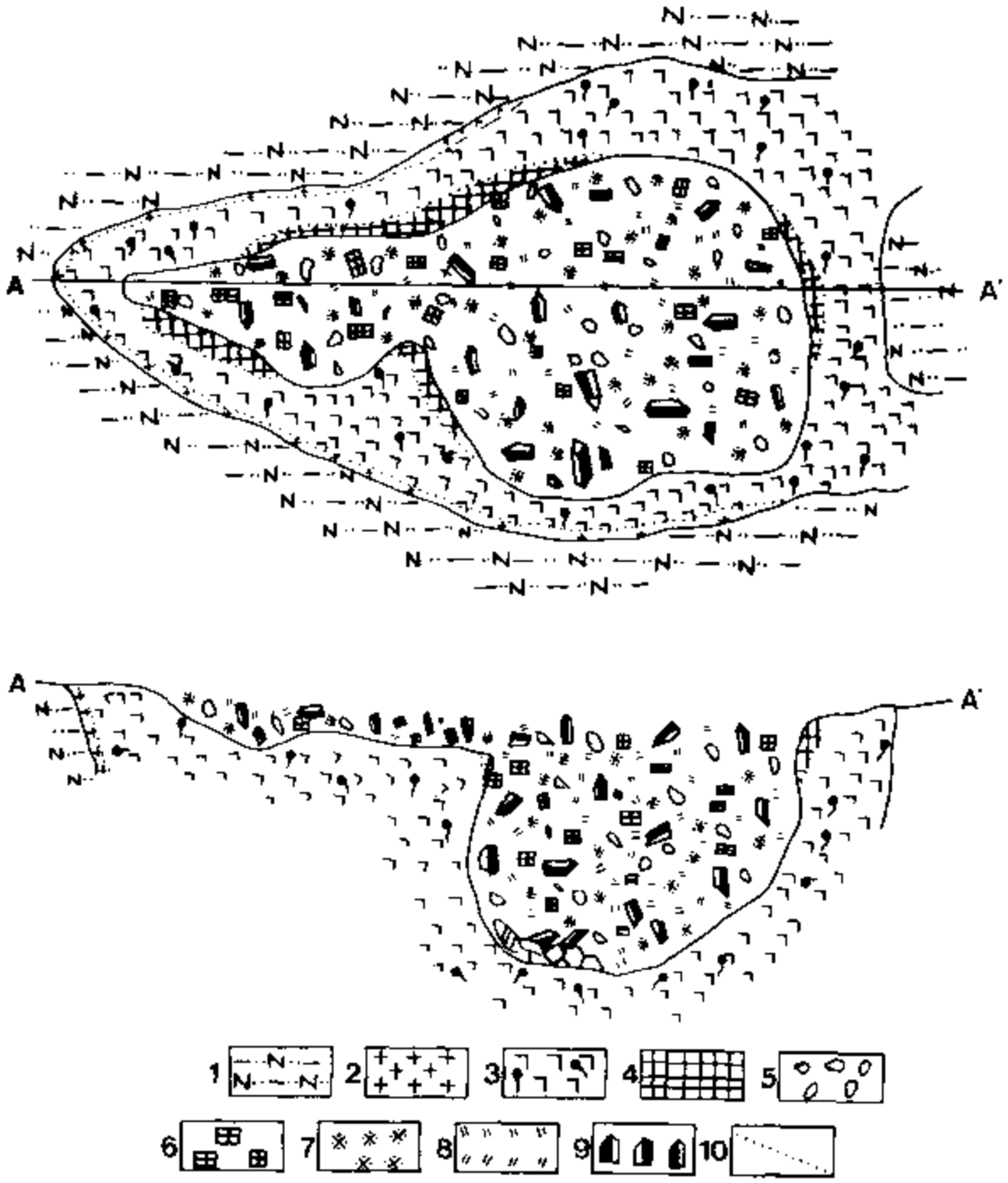


Figure 53 A sketch map of the geode in a rock crystal deposit of granite pegmatite, Xinjiang
The upper figure: Horizontal direction The lower figure: Vertical direction

1. Biotite feldspar quartz hornstone 2. Pegmatite marginal zone. 3. Graphic pegmatite zone.
4. Microcline zone 5. Quartz fragments. 6. Feldspar fragments. 7. Kaolin 8. Muscovite
9. Rock crystal 10. Intermediate geological boundary

iii. Replacement of pegmatite
The replacement of pegmatite in this area are albitization, muscovitization, and etc.

iv. Characteristics of crystal producing pegmatite
The characteristics of crystal producing pegmatite are as follows:

A. The shapes of crystal producing pegmatite are mainly isometric, barrel like and some are lenticular.

B. Crystal producing pegmatite has a well texture zoning. They are very often completely differentiated or well differentiated pegmatite. The five texture zones are basically complete. The quartz core is the quartz mas zone.

C. The sodium replacement is rather developed. It is very often confined in the inner edge of the metasomatic graphic zone, and the zone of feldspar and quartz mass.

D. The mineral association of pegmatite is simple. They are mainly microcline, perthite and quartz, besides are albite, biotite and muscovite. It also contains soft water amethyst and citrine (topaz). rarely aquamarine can be seen.

v. Rock crystal's growing position in pegmatite

A. Rock crystal grows in feldspar masses. Some crystals are occurred just within the feldspar masses and are closely surrounded by feldspar. Some crystals insert in the granite outside the pegmatite and they are usually smoky crystals in larger size.

B. Rock crystal is developed in the geodes of lower part of the quartz core. This is the main position for rock crystals growing, and there are associated gems like aquamarine, citrine and soft water amethyst.

C. Rock crystal grows in the feldspar geodes, which are occurred in the feldspar zone under the quartz nucleus. In the feldspar druses, rock crystal is the associated mineral. Some of them interpenetrate with each other, others grow on the feldspar. However, the rock crystal is in a small amount and the quality is not good.

D. Accompanying the sodium replacement is the growth of rock crystal. Generally, rock crystal develops in the metasomatic graphic zone which has been replaced by sodium.

vi. Evaluation of rock crystal's quality

The rock crystal formed in this mineral deposit usually has its diameter of about 1.5-10cm. Those with a large size and a long diameter are very often crystals of short prism shape or prism shape, with complete development of pedion. The types of rock crystal are smoky quartz, tea quartz, yellow quartz, amethyst and hair crystal. Inclusions for the above crystals are chlorite, black tourmaline, feldspar, muscovite and hematite.

2. The Rock Crystal Deposits of Hydrothermal Quartz Vein Type

The hydrothermal quartz vein type of rock crystal deposits plays an important part in the rock crystal deposits in Xinjiang. It was found everywhere in Xinjiang, especially those in the region of Kunlun Mountains are typical.

The hydrothermal quartz vein type of rock crystal deposit refers to that hydrothermal originated from various sources flowing in fractures and fissures during endogenic ore-forming period precipitates and concretes into rock crystal deposit under modified physical and chemical conditions responded to the variations of temperature and pressure and interaction with the country rock. Generally, they are regarded as middle – lower temperature hydrothermal deposits. With regards to this area, the scale of such deposit ranges a lot. The shape of orebody varies widely. The alternation of country rock surrounded deposit developed not well.

Here we introduce a rock crystal deposit in a certain area as an example.

(1) General Geological Situation

This deposit is located at the margin of Tarim Platform, in the Tam trough system of Tieklek fault block.

The main stratum exposed here are middle and upper series of Devonian and Jurassic, with sharp angle unconformity between them. The lithological character: middle series of Devonian mainly consist of greyish black bedded limestone and sandstone interbedded with each other. Upper Devonian is light grey, greyish green bedded sandstone, phyllite, light yellow sandstone, calcareous sandstone, thick bedded purple sandstone of middle granule with quartziferous conglomerate interbedded, and with lenses of limestone locally. The carboniferous mainly consists of grey, dark grey thick limestone, sandstone, shale and conglomerate. The lower Jurassic consists of great thick, or thick, bedded conglomerate, yellowish brown, grey quartz sandstone of middle granule, argillaceous sandstone, greyish black, black carbonaceous shale and argillaceous rock.

The deposit region has a complex geotectonic structure, with great faults developed, structure line mainly of NW-SE direction. Jurassic stratum are mono-formation structure, with dip of 230-250°, dip angle of 30-70°.

Within the deposit region, magmatic rocks are less developed, only veins of basic diabase occur.

(2) Characteristics of Quartz Veins

Quartz veins are distributed at the two sides of the unconformity plane of Jurassic and Devonian. Strikes of the veins are 130-165° and 230-240°. The ratio of length and width of the two groups of veins are 6:1 – 25:1. The quartz veins are mainly distributed in the sandstone overlying the base conglomerate of Jurassic system, secondly, the sandstone, slate and phyllite of Devonian.

The quartz veins are dominated by regular interformational veins intruded along the interformational desquamation fracture, with the form of lens, a few of them are intruded along the fractures that are vertical or diagonal to the stratum.

The country rock of quartz veins in less altered. For a few veins, the country rock is of the phenomenon of graphitization and silicification.

The quartz veins are white in colour, opaque – translucent, and have a sharp boundary with the country rock. The vein rock is mainly of granular texture, and the zoning of vein body is not clear. The prismoid and the primatic texture can be found only at the swells of veins.

Limnite and calcite can be found frequently in the quartz veins, and in a few veins chalcopyrite and galena can be seen.

In half of the veins, small miarolitec cavitys can be seen at the surface (such veins occur in the stratum of Jurassic), the diameter of the cavitys ranges from 1-3cm. Primatic crystals and pieces of crystals of transparent can be collected in the cavitys. Exposed at the surface, cracks of the crystals are well developed.

(3) For There Being More Quartz Veins in the Deposit Region, Now Only No. 3 Quartz Vein Taken as Example:

i. Vein body: Vein bodys of the platoid shape is several hundreds of meters in length, general strike 235°, dip angle 55-62°. It has a even and straight apical plate, but the base plate has a larger relief and branches, with sharp swells and contractions along strike jand dip.

ii. Vein quartz: It is in the milky white colour, opaque – translucent.The apical plate and the parts that become thinner are of the granular texture, the others of primatic texture, and in the middle segment of vein body the primatic texture is more developed. The "primatic bodys" are arranged crisscrossly, and metal minerals such as chalcopyrite, galena and sphalerite occur frequently in the vein rocks.

There are sandstone and shale inclusions in the apical plate, and also the silification and sericitization.

iii. Miarolitic cavities. The northwest segment of the quartz vein is of poor crystal-bearing character, only has segrigations and cavities. In the southeast segment, the vein rock is compact in structure, with large thickness and less change. The middle segment of quartz vein has a clear cross texture a great change in thickness and a lot of cavities. Hundreds of segregated miarolitic cavities of honeycomb shape can be seen locally, most of them occur near the base plate from 0.15-2 meters. The miarolitic cavities are mainly of the shapes of tube, bag, lens and ball. Some of them have branches, with smaller diameter generally. On the wall of miarolitic cavity, the prism and the root of crystal generally have a relation of successive transition. A little of the wall belongs to the part of sandstone inclusion. There are a few crystals dropped in the cavities, some crystals grow on the wall of cavities misscrossly. The crystal dropped in the cavity has the phenomenon of reformation, forming multiple 'heads' at its root part. The materials filled in the cavities are subindividuals, pieces of crystal, fregmentys of country rock, sandy-clay and black clay. The miarolitic cavities are mainly of relict form, which have become the transitional miarolitic cavities after reforming, that is the relict – solution form of miarolitic cavity. (see fig. 54).

iiii. Crystal: Crystals are dominated by those of colourless transparent and primatic form, secondly those of Dauphin short primatic form, and with Brazil twin crystals developed.

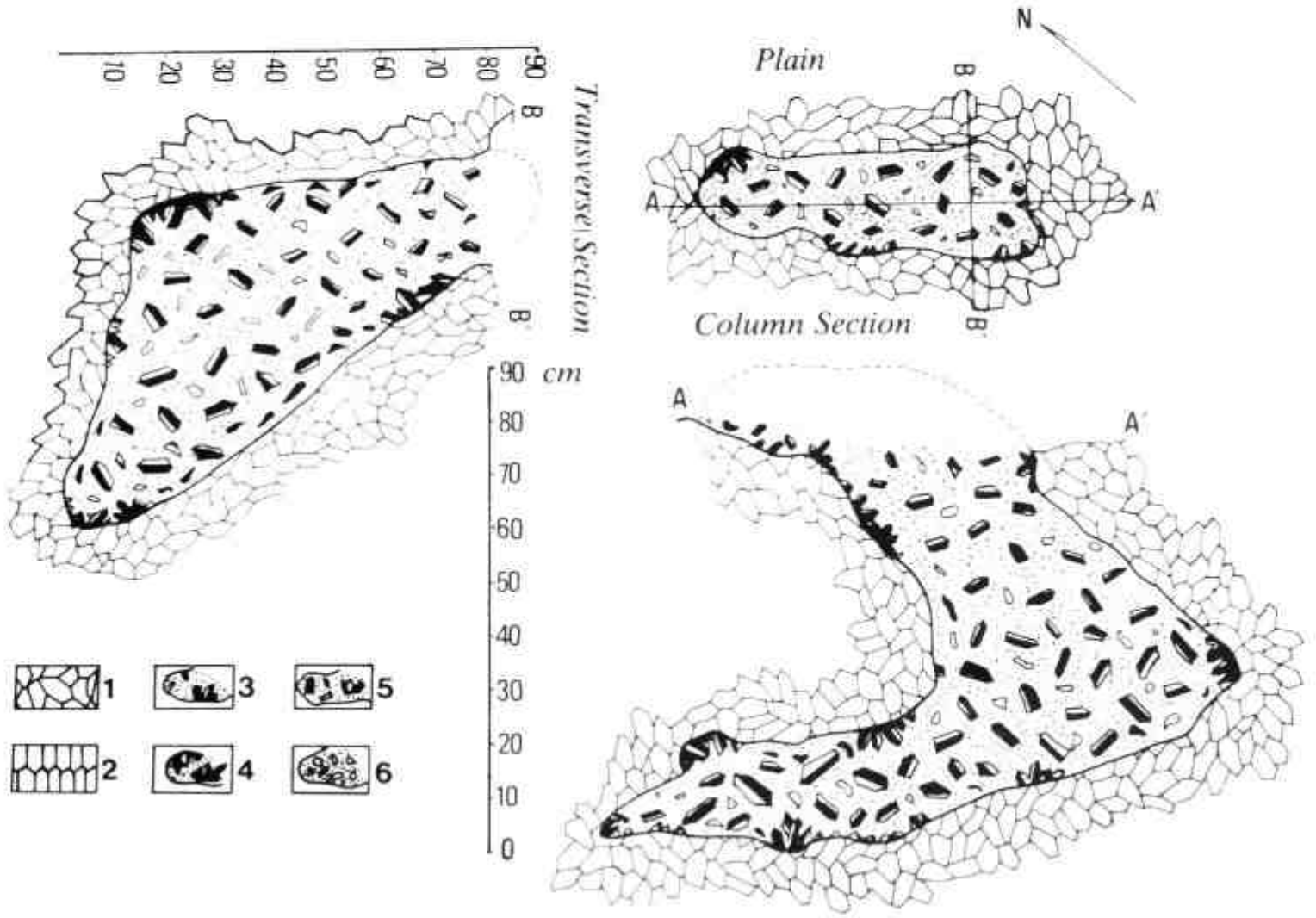


Figure 54 Sketch of miarolitic cavity of quartz vein in a certain place in Xinjiang Plain Cross section Longitudinal Section.

1. Primatic quartz vein of misscross form. 2. Primatic quartz vein of misscross form.
3. Crystal druse and crystals grown on the wall of miarolitic cavity.
4. Crystal druse with translucent base. 5. Crystals dropped in the miarolitic cavity.
6. Vein quartz and fregments of crystal filled in the miarolitic cavity.

Section Five Aventurine

I. General Introduction

Aventurine is a variety of secondary quartzite and it is also called Indian jade. Secondary quartzite in Xinjiang are green, pure white, pinkish red and black. The main composition of these secondary

quartzite is the same as that of Indian jade, thus we also call them aventurine. The discovery and utilisation of Xinjiang's aventurine was just the recent two or three years ago. After trial carving of aventurine, it was found that it has fine technological properties.

II. Physical and Chemical Properties

Xinjiang's aventurine appears in green (colour photograph 63, 64), black, pinkish red and white. It is translucent, with hardness 7 and a brittle nature.Its fracture is irregular or semi conchoidal. It has a compact massive structure, with the luster of glass. Its specific gravity is 2.66. Under polarized light microscope, it appears in micron or fine crystallo-blastic, and massive structure and banded structure. It is mainly constituted of micron quartz in compact state. Micronic grain quartz surround the fine grained quartz, and the fabric-like actinolites are distributed among the quartz grains. There was small amount of star-like pyrrhotite and pyrite, with veinlets of sulfied minerals. Veinlet is constituted of pyrrhotite, nickel pyrite, violarite, pyrite, chalcopyrite and stibnite. Besides, there are extremely small scale-like semi-graphite – aggregates of graphite spots fill the tissues.

On the polished surfaces of light green aventurines, a few associated minerals can be seen, such as specularite, actinolite, zoisite, sphene and rutile. There is still a few of phlogopite.

In black and greyish black aventurines, because the content of graphite is high, so the colour always appears in black or greyish black. If aventurine contains more actinolite, it will appear in green. It shows that the colour change of aventurine resulted by the content of trace elements is different. The shades of the colour depend on the content and the evenness of distribution of the associated minerals.

The chemical composition of aventurine is mainly SiO_2, see table 21.

Table 21 The chemical composition of Xinjiang's aventurine.

Oxide / Sample number	SiO_2	Fe_2O_3	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	TiO_2	P_2O_5	SO_3	ign. loss
1	93.27	0.35	0.55	0.36	1.30	1.39	0.10	0.10	0.04	—	0.03	—	1.98
2	95.54	0.36	0.65	0.55	0.25	0.23	0.04	0.04	0.10	—	—	0.28	0.38
3	95.85	0.36	0.65	0.53	0.34	0.23	0.04	0.04	0.08	—	—	0.30	0.39

The chemical analysis in table 21 shows that the SiO^2 content of aventurines basically satisfies the industrial standards. As a result, besides choosing minerals that are of good quality and bright colour as jade materials, this kind of quartzite deposit can also be used as general industrial materials.

The texture and mineral component of Xinjiang's aventurine under polarized light microscope. (see figure 55,56)

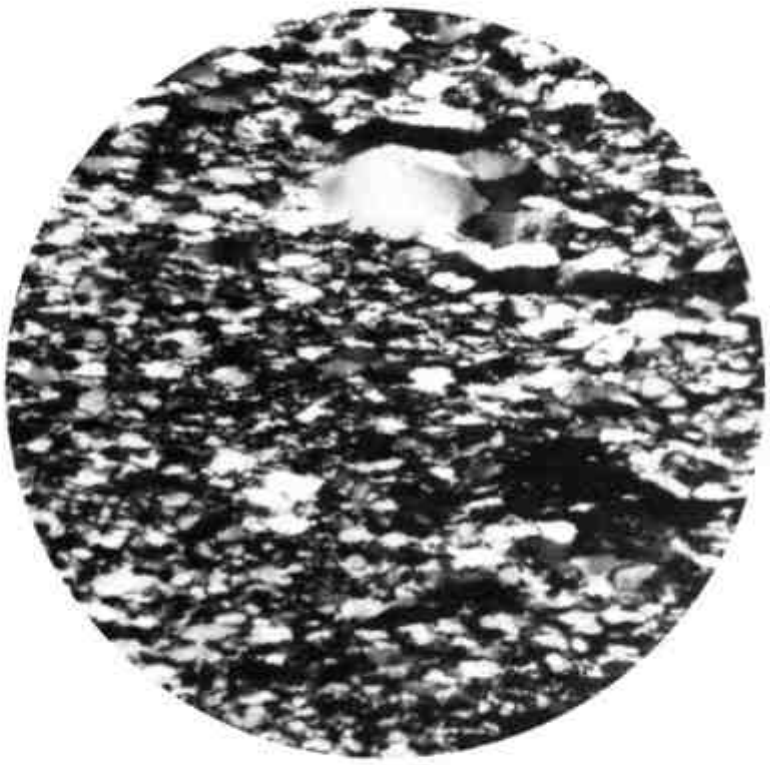


Figure 55 Aventurine
Micron granular quartz has oriented arrangement suffered to the force acting. It contains small scaly graphite, distributed in irregular band.
Cross nicols 35×

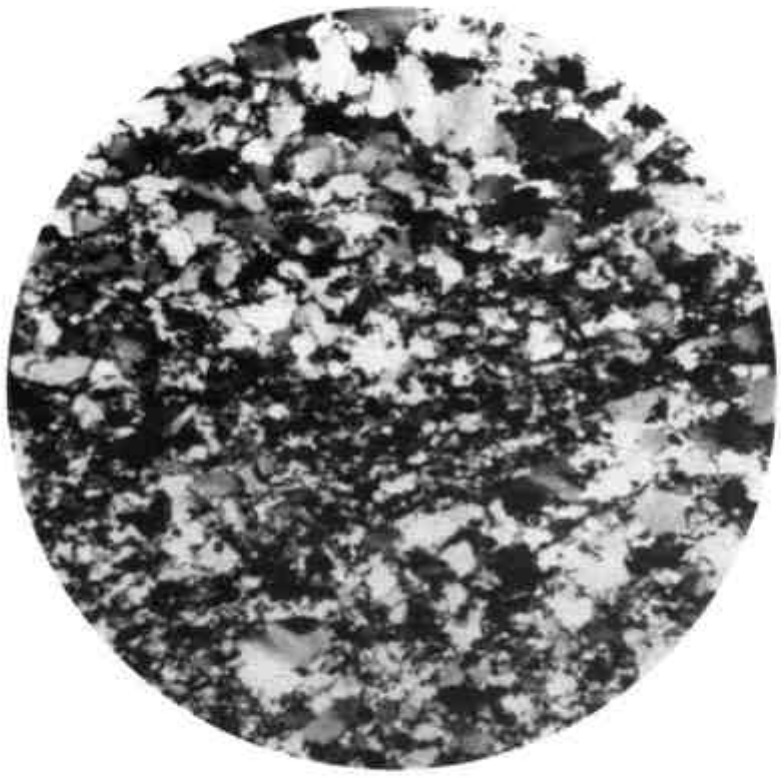


Figure 56 Light green aventurine
Micron metacrystal texture. Larger grains of quartz are surrounded by smaller grains, and among the grains, there are small scaly and fabric actinolite. Cross nicols 35×

III. Technological Processing Requirements

Aventurine is a low-grade jade. Here is the technical processing requirements and grading of Xinjiang's aventurines which are green and white in colour:

(1) Technological Requirements and Grading of Green Aventurines:

Grade 1: deep green and yellowish green in colour. The colour is bright, the texture is fine and smooth. It is slightly transparent and has no impurities. Lump weight is over 8kg.

Grade 2: Green, bean green in colour. The texture is comparatively fine and smooth. There is no impurity. Lump weight over 6kg.

(2) Technological Requirements of White Aventurine

On the whole, it is pure white and greasy white. The texture is smooth and there is no crackle. It is translucent. Lump weight over 4 kilos is of good quality.

IV. Geological Features of Aventurine's Occurrence

Aventurine deposits have been found in Xinjiang, but the degree for studying the utilisation is unadequated. According to information available, most of the known aventurine deposits are occurred in the deeply metamorphosed units rock of the Upper Proterozoic and the Lower Palaeozoic.

Section Six Agate

I. General Introduction

Agate has been a treasure from ancient times till now. It may be in bright colours of all kinds and is generally welcomed by people.The patterns and colours are various, and through the hands of masterly craftsmen, ordinary agate can become an art of treasure. Our country has a long-standing history in the production of agate handicraft. As displaced in Xinjiang's Historical Museum, there were agate decorations of the New Stone Age unearthed in Tolufan and the agate jewelleries – earrings, etc. of the Warring States (475-221 B.C.) unearthed in Urumqi.

Xinjiang's agate has plenty of agate occurrences and a broad distribution. The colours are plentiful, some are monocolour, but most of them are blazing with colour with special band and constitute complicated and fantastic patterns. With the uplifting of people's living standard and the continuous development of scientific technology, Xinjiang's agate does not only apply on the handicraft production, but on industry and medicine as well.

II. Physical and Chemical Properties

The mineral term used for agate is chalcedony. Agate is constituted by chalcedony aggregates in aphanitic fibre. Its chemical composition is mainly silicon dioxide, and always contains a little of ferric oxide , a mixture of organic materials.The chemical composition (%) of agate in anarea of Xinjiang is as follows:

SiO_2	Fe_2O_3	FeO	Al_2O_3	CaO	MgO	MnO	K_2O	Na_2O	SQ_3	Loss on ignition
97.93	0.03	0.62	0.41	0.21	0.08	0.05	0.06	0.06	0.06	0.81

Under polarized light microscope, chalcedony which appears in aggregates of aphanitic fibres, is aligned in band or spherulite. It is, generally, colourless, but because of the small amount of ferric oxide impurities mixed with it, it exhibits colours of many kinds, for example, light yellow, light brown, light blue, bluish grey, pink and black. The refractive index of chalcedony is lower than that of quartz, No=1.531, Ne=1.539, index of double refraction Ne – No=0.008, with lower negative relief, rough surface is not obvious. It has a order I greyish white interference colour, with parallel extinction, some with diagonal extinction, with both of positive and negative elongation (some elongate along C axis direction and others elongate along the direction perpendicular to C axis). It is uniaxial mineral, with position optical character, sometimes with small optical-axial angle. It is without cleavage, hardness 6.5-7, specific gravity: 2.6-2.65. The texture of agate is delicate, with a strong luster of glass. It is translucent, with a brittle nature and conchoidal fracture. They are usually in forms of lumps, concretion, stalacite, kidney and ovum. Some agates occurred in sand and gravel deposits have outer covering, some do not. Those that do not have an outer covering have a smooth surface , and are like pebbles washed by water, and those that have it are yellowish brown, greyish white and greyish yellow in colour. Agates with covering have to be cut in order to observe the quality, the colour and the pattern.

Agates have different colour bands (patterns).The width of the band ranges and the colour of the bands are various, including white, grey, sky blue, black, brown, yellow, light red, light purple and pink. And there are patterns of concentric, layered, undulant and motley. Narrow bands are just about one tenth of a mm wide, wider ones can reach several mm.The same band is constituted by a chalcedony

layer of the same colour ,and different colored bands are parallel to each other.Locally it has sudden winding and uneven parts. Because there are different material sources forming agate, the number bands are various. Some of them have coarse quartz band between the bands, which usually distributed in the centre part of agate, that is, in the most inner layer of concentric band (it is called sand core technologically), where there are crystalline quartz (as in colour photograph 25). The characteristics of sand core are that some are solid and others are hollow without solution inside, it is generally white in colour or milky white, and there is a divergence in transparency. Some agates have a hollow centre part, and on the wall there are many quartz druses, as crystal or amethyst. In some hollow agates, there exists water inside and is called water bag agate. Water bag agate is a rare treasure among agates.

There are different kinds of crackles in agates, as explosive crackles, central explosive crackles and broken crackles. The broken crackle is formed by force acting after the formation of agate. During the formation of ages, explosive crackles and central explosive crackles are formed because of the change in the condensation speed of colloid solution and the speed of crystallization. Some crackles radiate from the centre, some just have crackles in the centre, and the others do not have crackles in the middle part but have them in the outer layer. Crackles are extremely inadvantageous to the application of agates.

The colour of agates is related to the configuration of its colour bands, it has from colourless to red, blue, green, yellow and brown, (see colour photograph 65, 76, 77, 78, 79, 80) and some are multi-coloured. The colour of agates is best to be clear, bright and pure. Those that are colourless, or greyish purple and greyish brown,which are mixed by several colours,have inferior quality and are not suitable for handicraft manufacture.

Some agates have special optics nature which yields special effects – light flashing, which are especially obvious on the polished surface. When turning the polished surface, one or more than on black shadow move about, that is light flashing. The light flashing moves about, changes and becomes wider or narrower as the visual angle changes. The frequency of appearance of the light flashing is related to the frequency of joining of the agate's colour bands (colour band's turning point), the more frequent for the joining times, the more light flashing. There is only one light flashing within one joining line of two colour bands. No matter how to turn, to change the direction or the visual angle, the light flashing will not run out of the limits of two joining lines. (see colour photograph 72, 73, 74). Seen under polarized light microscope, the winding part of the colour band is its joining portion. It is a tiny crackle, on the two sides of which colour bands join together through the crackle. In the same colour band, fabric chalcedony and granular chalcedony are regular aligned perpendicular to the colour band, the mineral ranges parallel to each other, and cross at certain angle with the crackle (as in colour photograph 57). The clarity of the light flashing is related to the width of the colour band, the narrower the colour band, the higher the clarity. When the width of the colour band exceeds 0.7mm, the phenomenon of the light flashing will be blurred; when the width of the colour band exceeds 1mm, the phenomenon will disappear. Besides, if the colour band have a uniform colour, the light flashing will be clear, on the contrary, colour band constituted by different colours will make the light flashing not obvious. The production of the flash of light is due to the effection of refraction.

III. Classification of Agate

The saying "thousand kinds of agates" is ages old, and it is rather difficult to conduct a classification for so many agates. Here, we take into consideration the different schemes of agate classifications

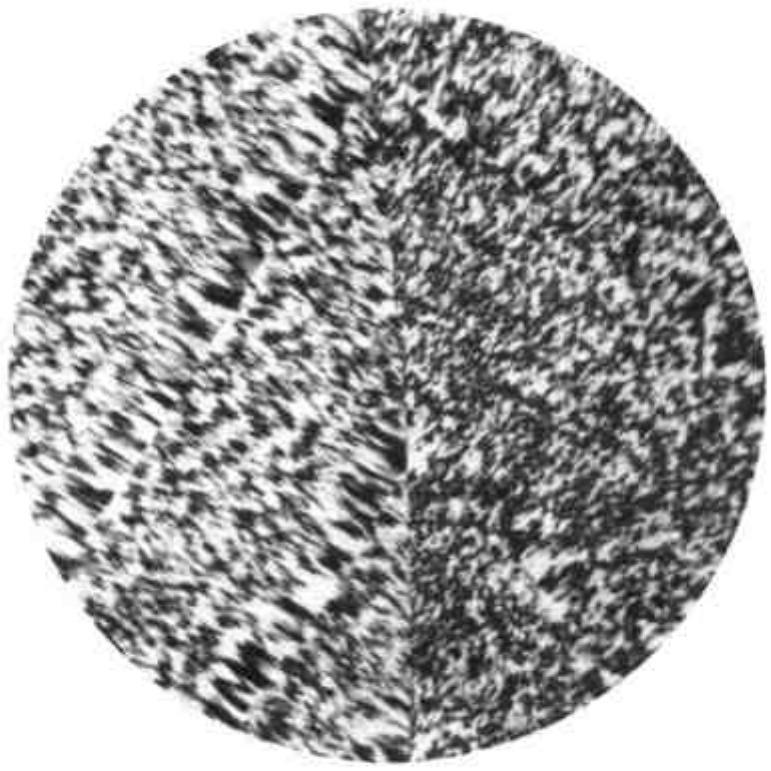


Figure 57 Agates' Bands, the minerals' alignment and the winding portion of the band (crackles), the bands at the two sides of a crackle join together. 20×

and carry out a preliminary classification by combining with the characteristics of Xinjiang's agate, which are the colour, texture and pattern. For those that do not have concentric pattern, bands inclusion are classified according to their colour, and for agates that have colourful patterns, bands and special patterns belong to another group.

1. Classification according to Colour

(1) Red agate–Xinjiang's red agate is mainly in red and appear in brownish red, dark red and yellowish red. The colour is the same inside and outside, and some are red alternating with white.

(2) Blue agate – mainly in light blue. There are two types: monochrome and sardonyx. Monochrome just has the colour blue which is deep and poor transparency. For sardonyx, very often it has blue alternating with white and sometimes it has other bright colours mixed with it.

(3) Yellow agate – mainly in yellow and appears in light yellow, orange yellow, brownish yellow and yellowish white. Sometimes beautiful colours like pink, light red and light grey mixed with it.

(4) Black agate is mainly in black, with light blue and light grey tints. The centre is concentric bands which is unobvious. Sometimes the colour of the centre is rather light, and it appears in ball, oval and irregular shapes.

(5) White agate – there are different shades, one is more transparent and colourless, and in crystal appearance (colour photograph.68). Milky white in colour, with light grey tints, some have concentric banded structure, the bands is not even and has quartz band in the centre. Transparent (crystal sugar) agate, the agate is colourless and transparent – translucent, compact and large size.

(6) Violet agate – it is just in purple but has different shades. It is uncommon.

(7) Grey agate – the agate is deep grey, light grey or light blue. Some of them have unobvious concentric bands. The interior usually has quartz band or sand core.

(8) Ghost face black agate – it is also called bile black agate. The colour is as green as bile, or of special strange colour – iron grey. The colour is not even and has blackish green tints. Some have unobvious and irregular concentric bands.

2. Classification according to Texture and Pattern

(1) Onyx Agate – it is a kind of agate that with parallel sheets, and is constituted by patterns of black and white alternating each other. (colour photograph 69).

(2) Silk Agate – in fabric – banded or concentric bands, the stripes between two bands meander slowly , some of them have the relief of abrupt winding. Its shape is like silk and some of the stripes are constituted by different colours.

(3) Sardonyx – another name for red sardonyx. Its colours are red, white and colourless alternating each other. The stripes may be as wide as a band or as narrow as a silk thread and are very beautiful. It is praised as the "gem of happiness" in jewelleries all round the world, and is listed as the birthstone of August. Because the lingering of silk is like tender affections, sardonyx is used as the symbol of love and harmonious happiness between husband and wife.

(4) Multi-generation Agate – it is a result of two stages mineralization. The colour and pattern of the agate formed in the first stage has obvious difference from that formed in the second stage.

(5) Torch Agate– it refers to the torch like texture of stripes that constitute the agate, (as in colour photograph 71) and so it is called torch agate. The torch stripe can be various colours, the larger the torch, the more good-looking it is, and its economic value is higher.

(6) Mushroom Agate – it refers to the inner stripes (bands) of the agate,which look like a mushroom. The stripes can be different colours. The width of the stripes may be various.

(7) Lace Agate – it is also called stripe agate, referring to agates in blue and white or black and white alternative with each other (colour photograph 70). Those that are black alternative with middle to light grey are called zygote agate, and those with black and white mixing together are called black and white agate.

(8) Water-bag Agate– the agate that is hollow inside filled with water is called water bag agate. The precious ones are big bladders with a lot of water. The better the transparency, the better is the quality and is a good material for jade-carving. Besides, there is an other kind of firewood-like agate. (colour photograph 66, 67)

IV. Technological Processing Requirements

Agate is a kind of jades, among those that are of good quality can be used as a gem, and usually they are used as jade. With the development of gem and jade handicraft, the technological requirements become higher and higher. The main requirements for technological processing of agates are as follows:

(1) Colour: The requirements are that the colour must be clear, bright and pure, and the deeper it is, the better the quality. However, the deep colour must be appropriate, those multi-colour agates must have one main colour, and main colour band must be thick other colours served only as a foil to the main colour.

(2) Crackles: The best are those with no crackles but more or less all the agates have crackles. The requirement is to have few crackles that are short and shallow and do not affect its application.

(3) Sand Core: The demand is to have no sand core. If there happens to be some, it should be able to be removed as impurities during the process of its application. Those with large sand core are useless (colour photograph 75), but some sand core can be used as supplimentary colour.

Apart from the above three demands, agates are also required to have a smooth surface and have no texture cleavage and impurities on the surface. The size must be large and with a good transparency. It must also have good linear and concentric bands and have obvious fine patterns. There should be no quartz bands, and if there is any, it cannot exceed 30% of agate's surface area.

Appraisal of agate

Imitation agates of ear-rings, hat ornaments, spherical pearl and lotus-flower beads are commonly seen. Materials imitating agates have a soft texture. The hardness of real agates is 6.5-7, that of imitation material is 5, and as a result, marks can be carved on it with real agate, besides, imitation agates have tiny ox hair-like stripes because of long time; real agates' cutting is dim, but that of imitation agates shines and usually has air cells and the colour is not bright.

V. Geological Features of Agate's Occurrence

There are more agate occurrences in Xinjiang. Here, we take the example of a agate deposit in a certain area of Xinjiang to discuss the geological feature of agate occurrence.

The agate deposit in an area of Xinjiang occurs primarily in the basic volcanic rocks area of carboniferous system of palaeozic group (Fig. 58).

The agate occurred in basal conglomerate of middle-lower Jurassic is epigenetic deposits. The sedimentary sequences can be divided into four formations, from top to bottom, the first formation is light grey calcium sandstone; the second one is conglomerate containing cream coloured agate, which is mainly volcanic clastic conglomerate or quartz conglomerate, the cement is calcium material, the size of gravel ranges a lot, with poor sorting, most of the gravels are in spherical or oval shapes, this formation contains small amount of cream coloured agate which are also spherical or oval, the formation has a stand extension along strike direction, the visual thickness is dozens of metres; the third is limonitized fine grained sandstone; the fourth is agate-bearing basal conglomerate, which is soil yellow and light brown in colour, with arenaceous and conglomeratic texture, gravel and fragments are consist mainly of quartzite, siliceous rocks, silified andesite and quartz monzonite, with minor quartz, opal and celedonite, and calcium cement, this formation contains red, yellow and grey coloured agate, locally black agate, it is an important horizon of mechanical sedimentary agate.

The lower canboniferous is medium-basic extrusive rocks, the top of which is olivine basalt, andesite-tuff, zeolitized andesite volcanic breccia and agate-bearing zeolitized andesite volcanic breccia.

The agate-bearing zeolitized andesite volcanic breccia is often surrounded by zeolite and calcedony which is in coarse spherical form (agate) of 0.1-0.3mm, sometimes associated with clinoptilolite. Such a rock is full of gas bubbles which is the favorable condition for agate formation.

The middle part of lower carboniferous consists of tuff, pyroxene andesite, zeolitized pyroxene andesite, agate-bearing amygdaloidal andesite and andesite, among which agate-bearing amygdaloidal

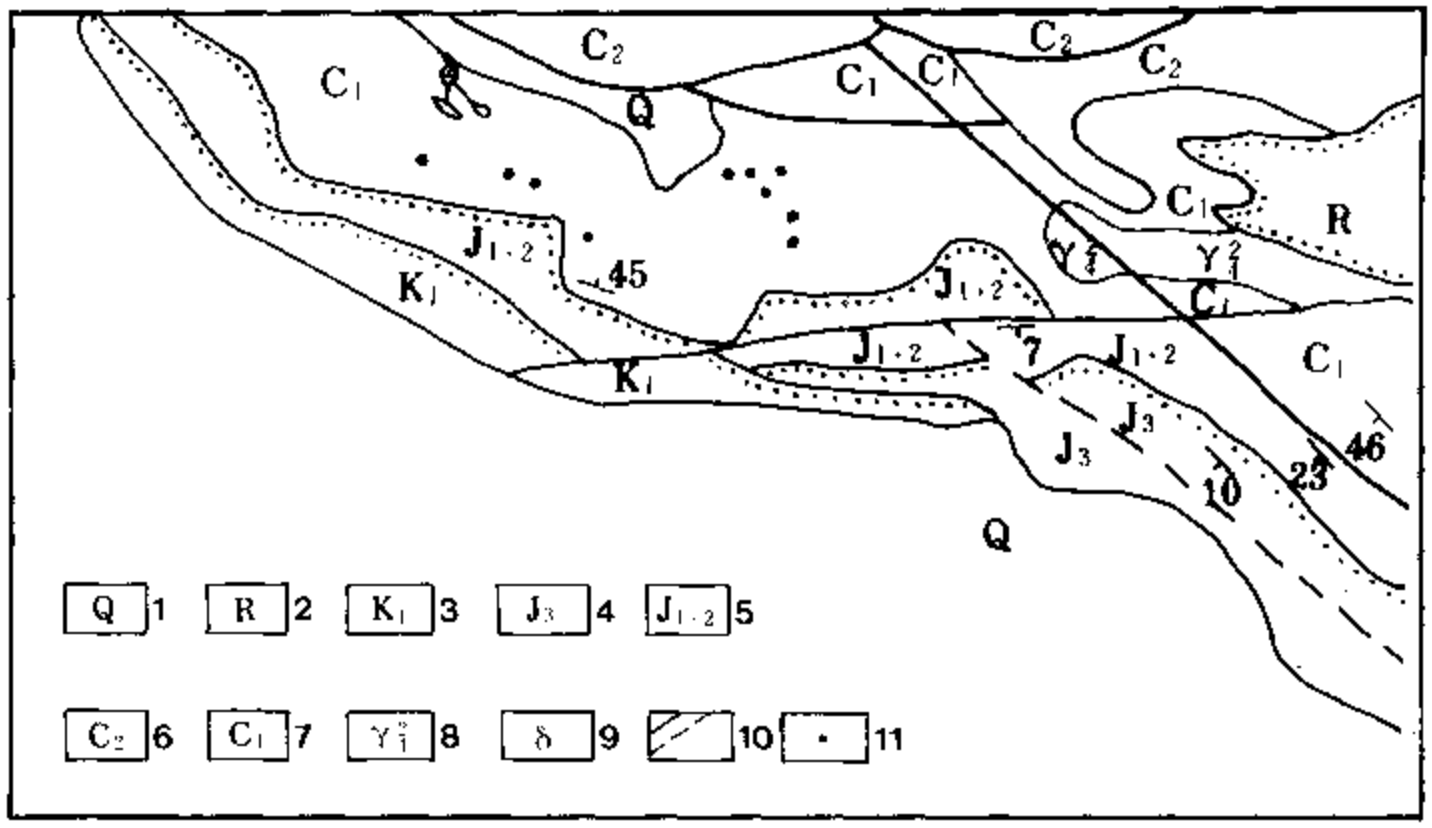


Figure 58 Sketch map of a agate deposits in a certain area of Xinjiang

1. Quaternary 2. Tertiary 3. Cretaceous 4. Upper Jurassic 5. Middle-lower Jurassic
6. Middle carboniferous 7. Lower Carboniferous 8. Variscian granite 9. Diorite
10. Fault and inferred fault 11. Agates occurrence

andesite is in pilotaxitic texture and amygdaloidal structure, consists mainly of lava and agate.

The lower part of lower Carboniferous consists primarily of andesite breccia and andesite.

Section Seven Tugu Jade (Yellow-Clay Jade)

I. General Introduction

Tugu (Yellow-clay) jade is the one found in Xinjiang in recent years. It was named like this because "Tu" in Chinese means clay refers to its colour of yellow topaz, and "gu" in Chinese means ancient, because it gives an antique feeling and is the right imitation material of curios. The handicraft that used Tugu jade as trial carving is camels, which are real and lifelike.

II. Physical and Chemical Properties

Tugu jade is yellowish brown in colour, compact, delicate, hard and in lumpy form. The colour is even and soft. It has the lustre of wax, its hardness is 7, specific gravity 2.66. There is no crackle in the jade, and some small brown spots are often present on the polishing and weathering surface. It appears in microlitic colloidal texture as in figure 59. Its mineral components are: quartz, limonite and a small amount of sericite. Quartz appears in allotriomorphic granular , its size is 0.02-0.05mm, and it has a hackly appearance, part of it has the phenomenon recrystallization. Sericite is in patch and scale. Limonite is in gelatinous texture, which results in the yellowish brown of Tugu jade.

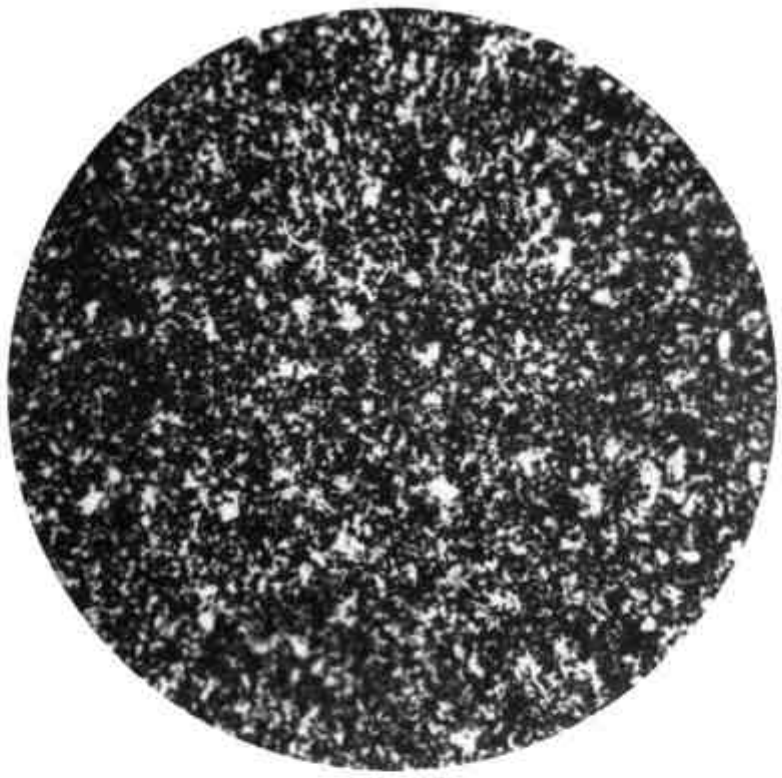


Figure 59 Tugu jade microlitic colloidal texture constituted by quartz and colloidal limonite. cross nicols 35 ×

The chemical composition (%) of Tugu jade is: SiO_2: 87.65 , Fe_2O_3: 7.15, Al_2O_3: 0.57, FeO: 0.46, MnO: 0.10, MgO: 0.76, Na_2O: 1.06, K_2O: 0.04,SO_3: 0.54, loss on ignition: 1.87.

III. Technological Processing Requirements

There is not yet any standard for Tugu jade's technological requirement. Standards are worked out according to that of aventurine: The colour appears in brownish yellow and is even and delicate with no impurites or crackles. The size must be able to be made into small jade objects,and the larger the size the better. Usually the size which is over 1kg. can be utilised.

IV. Geological Features of Tugu Jade Occurrence

The Tugu jade deposit occurs stratigraphically in Devonian which locates in the eastern part of the Tianshan Mt. It is intercalated in greyish green meta-sandstone and argillaceous slate as lenses, which has a strike of 306°, dip of 216, with steeply angle. The rock type of Tugu jade is ferrous and siliceous slate. The ore-body has a length of several hundreds metres in strike direction. Individual lens is several metres long, and dozens of centimetres wide, and had subjected from light metamorphism, which is intercalated in more coarse siliceous rocks.

Section Eight Wax-Yellow Jade

I. General Introduction

Wax-yellow jade is a new variety of jade defined recently in Xinjiang. Since the colour of the jade resembles wax and has the luster of wax, hence the name of wax-yellow jade. Its colour is bright with soft shades, and its texture is delicate. Trial-carving handicrafts are well received by jewellery-lovers in Japan, South-east Asia and Western Europe.

II. Physical and Chemical Properties

Wax-yellow jade belongs to deep yellow dolomitic marble (as colour photograph 82). Because it is honey-yellow in colour and has the lustre of wax, it is called honey-wax jade. Its colour is soft and moisturized, and has the shade of cream. It is opaque to translucent, its texture is delicate, and compact massive structure, cryptocrystalline to fine grained texture and rather few crackles. Its hardness is 4.3-4.5, specific gravity 2.6-2.9. The average value of compressive strength is 2478kg/cm^2. The mineral component of wax-yellow jade is mainly dolomite, accompanied average chemical composition (%) is:

CaO: 30.38, MgO: 19.33, SiO_2: 0.54,Fe_2O_3: 0.06, FeO: 0.13, Al_2O_3: 0.59, P_2O_5: 0.04, MnO: 0.02, CO_2: 44.89 and TiO: 0.04.

III. Technological Processing Requirements

The initial technological requirements of wax-yellow jade have been worked out as follows:

Grade 1: which is mainly in deep yellow, with high cream colour tint. The colour is soft. It has a wax-like lustre and shades of cream. It is translucent and crypotocrystalline to fine grained texture. Its texture is rather fine with few crackles. The size is over 10kg.

Grade 2: which is mainly in cream colour, with a small amount in light yellow. The colour is rather soft, it has a wax-like lustre and shades of cream. It is translucent and microlitic to fine grained texture. The size is over 5kg.

Grade 3: which is mainly in light yellow, with a small amount in cream colour and yellowish white. The shade is comparatively poor and it has quite a lot of crackles. It is fine grained recrystallized texture.

rarely medium grained crystallized texture. The size is more than two kg.

Handicrafts manufactured by honey-wax jade (colour photograph 81, 83, 84, 85, 86, 87, 88, 89, 90, 91) have a soft colour and are lifelike and well-received.

IV. Geological Features of Wax-yellow Jade Occurrence

Wax-yellow jade occurs in the southern flank of an anticlinorium in the middle upwarped zone of the Tianshan Mt. Its geological features are as follows:

1. Strata

The strata which outcrop in wax-yellow jade occurrence are Jixian System of Sinian Sub-group. They consist mainly of dolomitic marble intercalated with schist and wax-yellow jade layer mainly distributed in several parallel marble zones.

2. Structure

The mining district is located at the south limb of a anticlinorium, which is a monoclinal structure. The rocks in the district are tensely crushed due to a major fault passing through.

3. Magmatic Rock

Magmatic rock is quite developed outside the mining district, with large granite intruded, but it is much less developed inside the district. Only the south end of the district the magmatic is intruded partially by plagioclase granite, and locally diorite-porphyrite intrudes along bedding or cross bedding.

4. Characteristics of Ore Body

The ore body of wax-yellow jade occurs in the marble formation. It appears in lens, being rarely stratoid and irregular stratified and some intermediated gradually into dolomite. The boundary between the body and schist or silified dolomitic marble is clear.

5. Control Factors of Mineralization and Type of Genesis

(1) Mineralization Control Factors

i. Wax-yellow jade occurs in the greyish white and white flag to the thick bed of cryptocrystalline and to the fine grained marble of Jixian System. It is controlled strictly by stratigraphy and lithology.

ii. The ore body is locate at ends and flanks of marble lenses.

(2) Type of Genesis

Wax-yellow jade occurs in marble-lenses and appears in lenses and masses,and has an intermediate relationship with marble. The dolomite appears in yellow colour along the fracture plane because of the iron material oxidation, the colour is dark on the surface, but it gets light with the depth increased. Therefore, it is known that the forming of the jade's colour has little relation to hydrothermal activity. The dolomitic limestone was replaced by magnesium-rich solution into marble under the regional metamorphism, at the same time, dolomite absorbed divalent iron in the solution dyed marble into yellow colour under the oxidation on the surface.If the colour is dark yellow,it becomes valuable handicraft material of the jade.

The Jixian System of Sinian Subgroup occurs in many places of the Tianshan Mountains, Xinjiang, the areas adjacent to the deep major faults are the prospects exploring for wax-yellow jade.

Section Nine Tekes Green Jade

I. General Introduction

Tekes green jade was a new variety of jade found in 1980 by the Xinjiang Bureau of Geology and Mineral Resources, and was named according to the colour and the occurrence in Tekes region.

II. Physical and Chemical Properties

Tekes green jade is a kind of plagioclase and tremolite-bearing rock. The rock appears in bright green (colour photograph 92) and light blue. The texture is rather compact and it has compact massive structure.

The mineral association of Tekes green jade which is dominated by tremolite, actinolite and plagioclase contains a small amount of quartz, trace magnetite and apatite. It has a granoblastic texture, discontinuous banded and massive structure. The minerals are evenly distributed and are in orientated alignment. Actinolite and tremolite are in fibre, needle and prism and appear slightly in green under a microscope. Its grain size is 0.13-1.1mm. Plagioclase is sub-isometric to irregular grained, with polysynthetic twin, grain size 0.07 – 0.81mm. Quartz is isometric granular, grain size 0.13-0.63mm.

The chemical composition of Tekes green jade (%)

No.	SiO_2	Al_2O_3	MgO	FeO	Fe_2O_3	CaO
1	45.55	27.02	5.52	0.72	0.2	18.18
2	43.77	22.92	8.64	1.98	0.2	15.75

III. Technological Processing Requirements

Tekes green jade is in bright green and has comparatively even shades. The texture is rather delicate, with little or no crackles, and hackly fracture. It is slightly transparent to opaque, its hardness 5-5.5, it has the lustre of glass and a brittle nature.

Tekes green jade has a better and more even lustre after polishing. As a result, the handicraft made are crystal clear and lovely, and has a certain admirative value. (colour photograph 93).

IV. Geological Features of Tekes Green Jade's Occurrence

Tekes green jade occurs in northern limb of a syncline in an area of Xinjiang, which is NEE shearing compressive zone, structural features quite developed within the zone, middle Variscian ultra-basic rock intruded along the shearing compressive zone forming small stocks and dikes. Tekes green jade just occurs in the ultrabasic intrusions.

Section Ten Dushan Jade

I. General Introduction

Dushan jade is originally occurred in the Dushan Mountain, Nanyang county, Henen Province. It is thus named Dushan jade and is also called Nanyang jade. Dushan jade is one of the varieties of ancient jade.

Dushan jade which is produced in Xinjiang belongs to altered plagioclasite in the ultrabasic rock . This plagioclasite is much ejected from and higher than its adjoining rocks and is thus called Xinjiang Dushan jade because "Dushan" means "an isolated rock" in Chinese.

II. Physical and Chemical Properties

Dushan jade is a jade of various colours. It is a variety of altered plagioclasite or troctolite. It appears in irregular subhedral or euhedral prismatic and grained texture, locally in radial and lepidoblaxtic texture. The principal mineral components of Dushan jade are: zoisite, chiltonite, calcium hibschite and ophiolite, and rarely grastite. Zoisite is subhedral prismatic and grained, grain size 0.5 x 0.1mm, uneven distributed. Chiltonite occurs in fabric, radial and bunch, and often associated with calcium hibschite which is very fine grained and spread unequally exhibiting cloud-like green spots which enhances the Dushan jade's character – the colourful pattern of white background serves as a foil to green spots.



Figure 60 Dushan jade
Western Junggar, cross nicols 35 ×

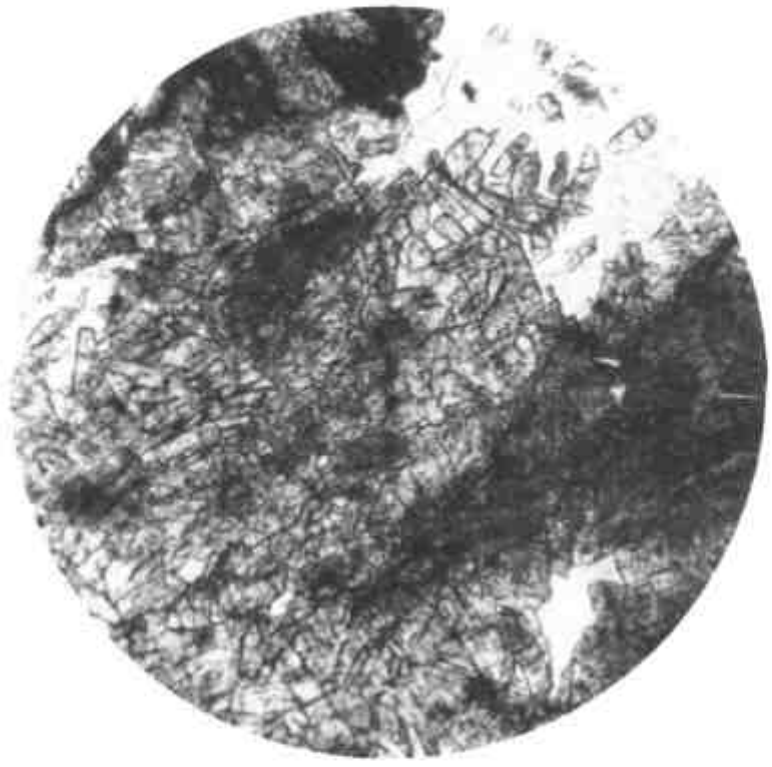


Figure 61 Dushan jade
Western Junggar, polarized light 35×

Dushan jade is usually in lump. Its colour is mainly white with green spots. With regard to the component, the white is plagioclase, the green serpentine. Some have white and green alternating with each other and mixed with yellow and purple. Because the mineral content of the different parts are not the same , the surface colour is different from opaque to some slightly transparent. It has a hackly fracture, its hardness is 5.5-6, actual measurement of special gravity 3.09, and the surface has the lustre of grease.

The chemical composition (%) of Xinjiang Dushan jade is : SiO_2: 41.42, Fe_2O_3: 0.71, Al_2O_3: 28.49, FeO: 1.02, CaO: 18.62, MgO: 3.62, K_2O: 1.02, Na_2O: 2.74, MnO: 0.08 and loss on ignition: 3.02.

III. Technological Processing Requirements

Dushan jade is a medium to low grade jade. Here are its technological requirements:

Grade 1: The colours are pure green or pure blue, green and greenish white. The texture is fine with no white veinlets and no crackles. Its lump weight is over 20 kg.

Grade 2: The colours are white, creamy white or green with a bright lustre. This grade has no crackles or impurities, lump weight over 5 kg.

IV. Geological Features of Dushan Jade's Occurrence

Xinjiang Dushan jade deposit is located at Western Junggar district, it occurs in plagioclase and pyroxene harzburgite of ultrabasic intrusion as vein-like injected body. It has a sharp contact with ultrabasic rock (plagioclase and pyroxene harzburgite), no alternative intermediation between both of them. The vein is about several metres wide, and several hundreds metres long, locally it appears in paternoster.

Section Eleven Sheep Liver Jade

I. General Introduction

Iron jasper is called sheep liver jade technologically. It is named because of its special colour of sheep liver. The colours are of various kinds which usually related to the trace mineral content.

II. Physical and Chemical Properties

Sheep liver jade has colours like, that of sheep liver, brownish red and vermillion. It has a compact massive structure. The mineral components are mainly chalcedony and limonite, with a small amount of quartz, rarely biotite, chlorite and secondary calcite veins. The inner texture is cryptocrystalline – microgranular or globular . There is also grained crystalloblastic texture which is a result of recrystallization responded to subzecting from force acting. There are some remained fabric global structure, massive structure and uncontinuous banded structure in some parts. Chalcedony always appears in cryptocrystalline fibre and globular aggregates. Limonite is disseminated evenly in tiny granular chalcedony, and appears also in thread shape, hair and branch arranged in parallel form. Other minerals scatter around, or occur unevenly in small aggregates. Especially for sheep liver jade, after recrystallisation, the mineral size becomes coarse and appears in isometric and irregular grains. The chalcedony content is generally 80-95%, limonite 10-15%, and other minerals 3-5%. Sheep liver jade has a brittle nature and conchoidal fracture, it is from opaque to completely transparent, with hardness 6.5-7, semi glass lustre and specific gravity 2.65.

The chemical composition of sheep liver jade is as follows (%): SiO_2: 95.66, Fe_2O_3: 0.58, FeO: 0.52, Al_2O_3:0.65, CaO: 0.32, MgO: 0.32, MnO: 0.10, K_2O: 0.06, Na_2O: 0.16, P_2O_5: 0.03, SO_3: 0.45 and loss on ignition: 0.77.

III. Technological Processing Requirements

The requirement on sheep liver jade's colour is that pure sheep liver colour, brownish red and vermillion are best. The size requirement of the mineral is extremely small. The structure should be compact, the texture delicate and there should be few or no crackles. After polishing, sheep liver jade has a higher degree of lustre, a higher reflectibility and a better clarity which is bright and even. Because the colour of sheep liver jade is not bright enough and has a bad transparency, it is just treated as a jade of lower grade.

IV. Geological Features of Sheep Liver Jade's Occurrence

The origin of sheep liver jade is related to marine extrusive rock, and is closely related especially to the marine extrusive iron deposit. In a iron deposit in the western part, and the some carboniferous iron deposit in the east part of Xinjiang, associates with a large amount of sheep liver jade.

Section Twelve Minor Graphic Stone

I. General Introduction

Small graphic pegmatite is called minor graphic stone when applied technologically. It has beautiful patterns which are a texture formed by regular intergrowth of quartz and microcline, that is, the graphic texture of ichthyoglyptus. Minor graphic stone has a bad transparency and the colour is not bright, so it can just be used as decorative material. Stones of extremely good quality and large size can be used as a low-grade jade or decorative stone.

II. Physical and Chemical Properties and Geological Features of Occurrence

Minor graphic pegmatite is usually creamy white, its texture is compact and structure is massive. It is constituted by quartz, microline and a small amount of muscovite. The chemical compositions of small graphic stone are mainly silicon dioxide and aluminium trioxide, and are completely the same with aplite. It has semi-glass lustre – grease lustre, hackly fracture and a brittle nature. Its size is comparatively large with no crackles. Its texture is rough and its transparency is bad, with a low transparency and a dull colour. It can only be a low-grade jade in technology , used as the base of jade objects or as a decorative stone. The minimum size of technological requirement is 150x150x150 $(mm)^3$. The most common ones are light greyish white in colour. The stone is generally occurred at the edge of the contact zone between granite pegmatite and granite.

Section Thirteen Turquoise

I. General Introduction

Turquoise is a phosphate mineral containing copper and aluminium. Its chemical composition is $CuAl_6$ $[Po_4]_4$ $(OH)_8$: $4H_2O$. In the field of gem technology, it is called Turkey jade. It is one of the important varieties of jade traditionally in the international market.

The utilization history of turquoise has been ages old. It is reported that in the Sunjiazhai village of Datong county in Qinghai, there were the tombs of the primitive society. Among the unearthed objects that were of five thousand years ago, there were decorative stones made of turquoise, agates and bone. The name of turquoise started in the Qing Dynasty.

Turquoise is a variety of jade that exhibits Chinese national characteristics and enjoys international reputation. It is well received abroad. Among the customs of the jewelry world, it is praised as the "Stone of success" and the "birthstone of December", symbolishing success and certainty of winning.

II. Physical and Chemical Properties

Turquoise belongs to triclinic system. Its colours are bright sky blue, light blue, lake-water blue, apple green, blueish green and yellowish green. According to information available, the formation of the skyblue in Turquoise is mainly determined by the existence of copper (Cu^{2+}) co-ordination octahedron of the crystal, and iron has a key effect on the mineral's shade change. Iron exists in the crystal lattice mainly in the form of Fe^{3+} in exchange with Al^{3+}. With the increase of the iron content, the colour of turquoise can change gradually from greyish blue to skyblue – blueish green – green – brownish yellow. Turquoise is a fragile jade, the colour will change when heated and is easily eroded by outside material. Thus its technological processing should be conducted under stable temperature, and has to prevent from acidic erosion. In an area of Xinjiang, turquoise appears in light blue, brownish yellow, greyish white, and usually occurs in cryptocrystalline mass and cortex. The texture is delicate, hardness and has conchoidal fracture. Its hardness is 5-6, specific gravity 2.6-2.7. It is translucent to opaque, with white streaks and wax lustre.

At the edge of veined turquoise, there is a layer of hydrous goethite-like material which is 0.02-0.05mm thick, and inward, there is a thin layer membrane 0.2mm thick of micro-grained quartz. Concretionary turquoise has a layer of black or brownish red covering. The black is carbon, the brownish red is iron. The covering can extend to the inner part and form polygonal, net and veined crackles.

If penetrated by coloured solution, turquoise's own colour will be destroyed and (OH) will escape when heated, thus leading to colour change.

The simplified chemical analysis of turquoise in an area of Xinjiang is as follows (%):

Composition	CuO	P_2O_5	SiO_2	Al_2O_3	FeO	Fe_2O_3	MnO	CaO	MgO	ZnO
Green	6.07	23.86	10.60	19.22	0.42	14.93	0.02	2.25	0.49	0.24
Yellowish green	5.03	23.00	0.68	14.60	0.22	26.06	0.01	2.87	0.61	0.12

Optics nature: Turquoise appears in dull light yellow, yellowish green and greyish green under polarized light microscope,cryptocrystalline and high relief. Its refractive index is 1.632 ± 0.002. The interference colour is covered by bright natural colour and appears in greenish yellow.

III. Technological Processing Rquirements

Turquoise's technological requirements are mainly based on the standards of colour, texture, impurities and the size of the crystal. On the whole, the shades of the colour are divided into several levels of bright, dull, dim and even. According to the degree of compactness and hardness, it is divided into grades of hard and soft turquoise. In Xinjiang, there are both of them, with more of the former.

Besides as jewellery of medium grade, turquoise can also be made into jade-carving handicraft like spherical pearl, oval-shaped stones, vases, stoves, persons, birds and animals. The people of the Zang (Tibetan) nationality and the Mongol nationality like to wear turquoise ornament. For example, among the national form of Mongolian inlaying handicraft, turquoise, coral and lapis-lazuli are used to setting stones. In the Imperial Palace, turquoise can be seen inlaid on gold and silver utensils and are gorgeous and beautiful.

IV. Appraisal Standard of Turquoise

According to the chemical composition and hardness, etc. turquoise can be distinguished from other stones that have similar colours, such as malachite and siliceous malachite.

The difference of turquoise products and its fake is: its lustre is dim and dull, its hardness is low and it seems to be in powder form, earthy fracture, colour looks like false, and without ferrous weathering material contamination.

V. Geological Features of Turquoise's Occurrence

Xinjiang's turquoise is mainly occurred in the bottom of the Cambrian, which are carbonaceous and siliceous rocks. They are carbonaceous shale and turquoise alternated quartzite. The occurrence of Turquoise is closely related to the interformational cracks and the crushed zone. It is one of surface weathering profiles.

Here is a simplified geological explanation of the turquoise occurrence in an area of Xinjiang.

That mining area is an old one, which occurs at an overturned syncline east of Cambrian lake. The strata outcropped in this area are Sinian and Cambrian, between which there is a uncomformability. The Cambrian consists of limonite (ironstone), carbonaceous shale, turquoise altered quartzite banded quartzite, quartzite and moscovite schist.

The ore-bearing stratum is the carbonaceous and siliceous members at the bottom of Cambrian, which are lithologicaly limonite-alternated carbonaceous shale and turquoise alternated quartzite. Turquoise occurs primarily in interformational crackles and fractured zones of turquoise alternated quartzite and carbonaceous and siliceous rocks. Ore bodies are mainly lens or fine veins, the size of which is generally small.

Chapter Five The Genetic Types, Minerogenetic Features and Direction of Prospecting of Gem and Jade Deposits

Section One The Genetic Types of Gem and Jade Deposits

The gems and jades of Xinjiang, including dozens of minerals and rocks, have various kinds of genesis. There are endogenic deposits and exogenetic deposits. As a result, to conduct a classification on the genesis of Xinjiang's gem and jade deposits has very important practical significance. It is an important factor leading to a prospecting of the gem and jade deposits and the evaluation work of the gems and jades.

We combine the new development of geological work on Xinjiang's gems and jades and the general principles of classification of mineral deposits, and divide Xinjiang's gem and jade deposits into two main groups: the endogenic deposit and the exogenetic deposit. We then sub-divide the former into magmatic type, granite pegmatite type, pneumato-hydatogenetic type, hydrothermal type and metamorphic type based on the genesis of their host rock,the characteristics of the deposit's composition and the conditions of formation. For the whole group of exogenetic deposit, it is sub-divided into weathering crust and placer type. See table 22.

Table 22 Genesis and classification of gem and jade deposits of Xinjiang.

Effect of formation	Type of formation	Type of formation	Types of gem and jade	Practical significance
Endogenic deposits	Magmatic type	Kimberlite	Diamond	Significant for exploration
		Ultrabasic rocks and relative basic rocks	Serpentine jade Tekes green jade Dushan jade	The main source of these jades
		acidic extrusive rocks (obsidian)	Glass jade	The main source of this jade

Exogenetic deposits	Granite pegmatite type		Rare metal pegmatite	Aquamarine, aquamarine cat's eye, various kinds of tourmaline, rose quartz and small graphic stone.	The main source of aquamarine, aquamarine cat's eye, tourmaline, small graphic stone
			Mica pegmatite	Amazonite, aquamarine.	The main source of amazonite
			Geode pegamtite	Chlorosapphire, rock crystal, garnet, tourmaline, purple apatite, lilac purple jade and precious spodumene.	The main source of chlorosapphire, garnet, tourmaline and lilac purple jade.
			Empty bag pegmatite	Colourless rock crystal, smoky quartz, hair crystal, amethyst, citrine, aquamarine, soft water amethyst	The main source of rock crystal, citrine.
	Pneumato-hydrothermal type		*Greisen*	*Chlorosapphire*	*The main source of* chlorosapphire and water bag chlorosapphire
	Hydrothermal type		Quartz vein	Rock crystal	The main source of rock crystal
			Phlogopite-sodalite vein	*Dumotierite*	Significant for prospecting
			Post volcanic	Agate, sheep liver jade	The main source of agate
	Metamorphic type	Contact metasomatic	Skarn	Grossularite (Altai emerald), cinnamon stone.	The main source of grossularite (Altai emerald) and cinnamon stone.
		Contact metasomatic	Contact metasomatic in ultrabasic rocks	Jasper jade, Jinshan jade	The main source of jasper jade.

Endogenic deposits	Metamorphic type	Contact metasomatic	Contact metasomatic of granito-diorite with dolomite marble	Hotan jade (greasy jade), white jade, greish white jade, grey jade, brown sugar jade, black jade and Kunlun jade.	The main source of Hotan jade and Kulun jade.
		Low temperature facies		Silicified wood, aventurine	The main source of silicified wood and aventurine.
		Medium-high temperature facies		Partschinite	The main source of partschinite
				Ruby, blue sapphire	Significant for prospecting deposits
				Wax-yellow jade, white marble.	The main source of wax-yellow jade
	Weathering profile	Weathering and leaching		Siliceous malachite, chatoyaney malachite,turquoise,	Significant for prospecting
	Placer	Eluvial and drift placer		Garnet, sapphire agate	Economic significant
		Alluvial and diluvial placer		Rock crystal, Hotan jade, jasper, diamond,	Economic Scale, significant for prospecting

From table 22, we can see that most of the gems occurred in Xinjiang that can be of use are concentrated in the deposits of granite pegmatite type and pneumato-hydrothermal type. The types of origin for jades are comparatively scattered. The placer deposit type plays an important part, especially for nephrite. It has a more occurrence in the Quaternary glacier deposits and the upper and middle reaches of the rivers.

Section Two The Minerogenetic Features of Gems and Jade Deposits

Xinjiang has a great variety of gems and jades and their compositions are complicated. They have a various genesis and they are occurred from magmatic type to exogenetic deposits. Most of the deposits are indogenetic, such as, magmatic type, granite pegmatite type, pneumato-hydrothermal, hydrothermal or metamorphic type. For exogenetic deposits, there are leaching types which is related to weathering

profile, eluvial and drift bed placer, and alluvial and diluvial placer. Most of the gem deposits are closely related to metasomatism of granite pegmatite and pneumatogenic hydrothermal. For jade deposits, most of them are related to the regional metamorphism and the contact metasomatism, some are related to the Quaternary glacial deposits and alluvial placer. Here, we discuss them individually according to the features of the deposit type.

I. Magmatic Type Deposit

Up till now, jades found from this kind of deposit are Tekes green jade, Dushan jade and glass jade. It is related mainly to ultrabasic rocks, plagioclasite, obsidian and andesite.

Ultrabasic intrusion has a wide distribution in Xinjiang, it is mainly occurred in the east and west part of Junggar, Tianshan, Kunlun Mountain and Arjinshan mountain areas. The jade deposits that are related to ultrabasic rocks are serpentine jade, Tekes green jade and Dushan jade deposits. Some of these jade deposits are formed because of the influence of other geological factor, such as Tekes green jade ; some are the result of serpentinization which is caused by autometamorphism of ultrabasic rock itself, leading to a change in the mineral composition. The texture becomes delicate. It is transparent – opaque. The example is serpentine jade. Some serpentine rocks occurred on the outside edge of chromite orebody forms some "eggshell". They can be used as jade material if the colour is beautiful and soft.

In an area of Xinjiang, pyroxenolite of the middle Valiscian was found . They are either small stocks or veins, and are influenced by the effect of automorphism. In the centre of the rock, jades constituted of green tremolite aggregates are found – Tekes green jade. Apart from it, plagioclasite and troctolite dikes which are formed in the later stage of ultrabasic intrusion, plagioclase becomes illuderite and calcium hibschite after the hydrothermal alternation and olivine becomes serpentine resielting green patterns is set on the white base illuderitized plagioclase, which is called Dushan jade and can be used as jade material.

Obsidian is distributed in certain acidic volcanic areas in east Junggar.Some obsidians have their glass component compact and fine, with few or no gas bubbles, and can be used as the material of glass jade.

In an area of Xinjiang,small Kimberlite tubes are found. Although diamonds of gem level have not yet been found, it is significant for prospecting.

II. The Granite Pegmatite Deposit

Many gems and jades in Xinjiang, such as the different kinds of emerald, colourful tourmaline, garnet, topaz, purple apatite, precious spodumene, amazonite, colourless rock crystal, amethyst, hair crystal, rose quartz and lilac purple jade, are all closely related a granite pegmatite. The rockforming minerals and certain mineral aggregates of granite pegmatite, such as small graphic stone, can be used as jade. They are the by-products recovered at the same time with the mining of rare metal minerals, muscovite and rock crystals. Granite pegmatite is mainly distributed in the two geosyncline fold zones of Altai and Kunlun Mountains, besides, in the east and west of Junggar, the eastern section of Tianshan. It also scatters in the centre of Tianshan.

Gems-bearing granite pegmatite and geode granite pegmatite have different metallogenetic specialization, and have their own special indicator. The shallow part of geode granite pegmatite is called "gems bearing pegmatite", which are rich in silicon and alkaline metal, with potassium obviously more than natrium. In the volatility composition of geode pegmatite, the content of fluorine is high:

1. Rare Metal Granite Pegmatite Bearing Gems

They are mainly distributed in the areas of the Altai mountains and the Kunlun Mountains. Gems-bearing granite pegmatites occur in endo- and exo- contact zones of gneissose biotite orthoclase granites and gneissose dimicaceous granites Granite pegmatite of the indocontact zone has a poor differentiation and weak mineralisation; that of the exocontact zone has a well differentiation and strong mineralisation. This kind of granite pegmatite appears in veins, lenses, plates, rarely in large stocks, and can reach a scale rare to the world. Very often, the stocks have the phenomenons of the branching and composition, and swelling and shrinkage.

The country rocks of granite pegmatite schists consist of high aluminium minerals, such as andalusite, cordierite, Kyanite and sillimanite, biotite quartz schists and gabbros.

Different gems and jades occur in various evolution stages of granite pegmatite. In the stage of crystallisation differentiation, amazonite, aquamarine, garnet and rose quartz are formed; in metasomatism stage, colourful tourmaline, blueish green and yellowish green emeralds are formed.

2. Geode Granite Pegmatite

Geode granite pegmatite intruded into the country rocks. Its characteristics are that it does not have complete zoning and the graphic pegmatite is developed. Very often it does not contain any quartz core, and appears in veins or lenses, especially there are geodes in the swollen part. Sometimes many geodes can be seen in the vein, along a certain directions on the horizontal plane line. For example, in an area of Xinjiang, the vein of granite pegmatite belongs to geode pegmatite. Around the geode, there are albitization and autometasomatism. General minerals and gems are microcine, albite, muscovite, tourmaline (pink, green, yellow, yellowish green and purple in colour), aquamarine, yellowish green beryl, precious spodumene and purple apatite, and there are lepidolite aggregate formed by metasomatism – lilac purple jade.

Geode granite pegmatite is the main source presently for tourmaline, lilac purple jade, yellowish green and transparent emerald, purple apatite, precious spondumene and spessartite in Xinjiang.

3. Empty Bag Granite Pegmatite

Empty bag granite pegmatite was first proposed by a Russian Geologist, H.L. Yermakove in 1957, using a mineral deposit in Ukraine as an example, and assigned it as an independent formation type. It occurs in eastern and western Junggar and the east section of the Tianshan,their occurrence characteristics are as follows:

(1) All occurred in the middle, later Valiscian acidic intrusive rock;

(2) Many granite pegmatite veins gather in the parent granite;

(3) Most of them are occurred in the porphyritic-like biotite granite and the marginal facies of potassium granite. At the intersection of the "X" type joint, granite pegmatite appears in tubes unsymmetrical form and oval form, sometimes it occurs in luster of in elongated form.

(4) Most of them are mono-crystal geode and the size of the geode is various.

(5) From the texture of the vein , it belongs to the kind of granite pegmatite that has a good differentiation, and has a larger quartz core.

(6) This kind of geode- empty bag is a good place for free crystallisation of minerals, and huge gem and jade crystals can be grown. An example was that in the granite pegmatite of an area , a mono-crystal of quartz about tens of tons, topaz of 8kg, and a fluorite crystal about 100kg were extracted.

(7) Apart from the various kinds of rock crystal, aquamarine and topaz for decorative purpose are occurred.

III. Pneumato – Hydrothermal Deposits

Xinjiang's pneumato-hydrothermal gem deposits mainly are beryl-bearing greisen deposits.

Most of the beryl bearing greisen deposits found,up to present,are in the granite deposits that contain beryllium and are on the top part of the granite of Yanshan period. Such deposits are the results of migration and concentrating of ore-bearing pneumatolytic hydrothermal which remained in the stage of post-magmatism of granite along joints and fractures in country rocks. At the stage after crystallization and autometasomatism, the sodium alteration had been weakened greatly, but the processes of fluorine, silicon and volatiles had been strenthened. Thus, the rock condominated by the minerals rich in fluorine and silicon constitutes the emerald-bearing greisen. Its mineral components is complicated, the crystal are big. The main rock-forming minerals are quartz, muscovite, besides, there are microcline, and a small amount of albite, topaz, flourite, tourmaline, calcite, chlorite, biotite and sericite, and trace of metallic sulphides.

The country rock surrounding the deposit had been tensely alterated, the alterations are mainly greisenization and pyritization, besides sericitization and silicification.

Such deposits in Xinjiang are the richest deposits with beryllium . The biggest deposits which have been found so far are the emerald-bearing greisen lode in area of Altai. Here, we take it as an example to illustrate the geological features of the deposit occurrence.

1. The Geology of a Beryl Bearing Greisen Vein

The vein which locates at the axis of an anticline and is a part of an anticlinorium at the ends of faults is related closely to the granites of Yanshan period. It occurs at the top and projected portion of flanks of the two micas grahite and muscovite granite , which appears in cupola, stock and network as figure 62 and 63.

The outcrop area of the granite is often small. Beryl bearing albitized granite is situated at the top part of the muscovite granite, and is a product of autometasomatism during the crystallization muscovite granite. Both of them appears to have gradual changing interim relationship.

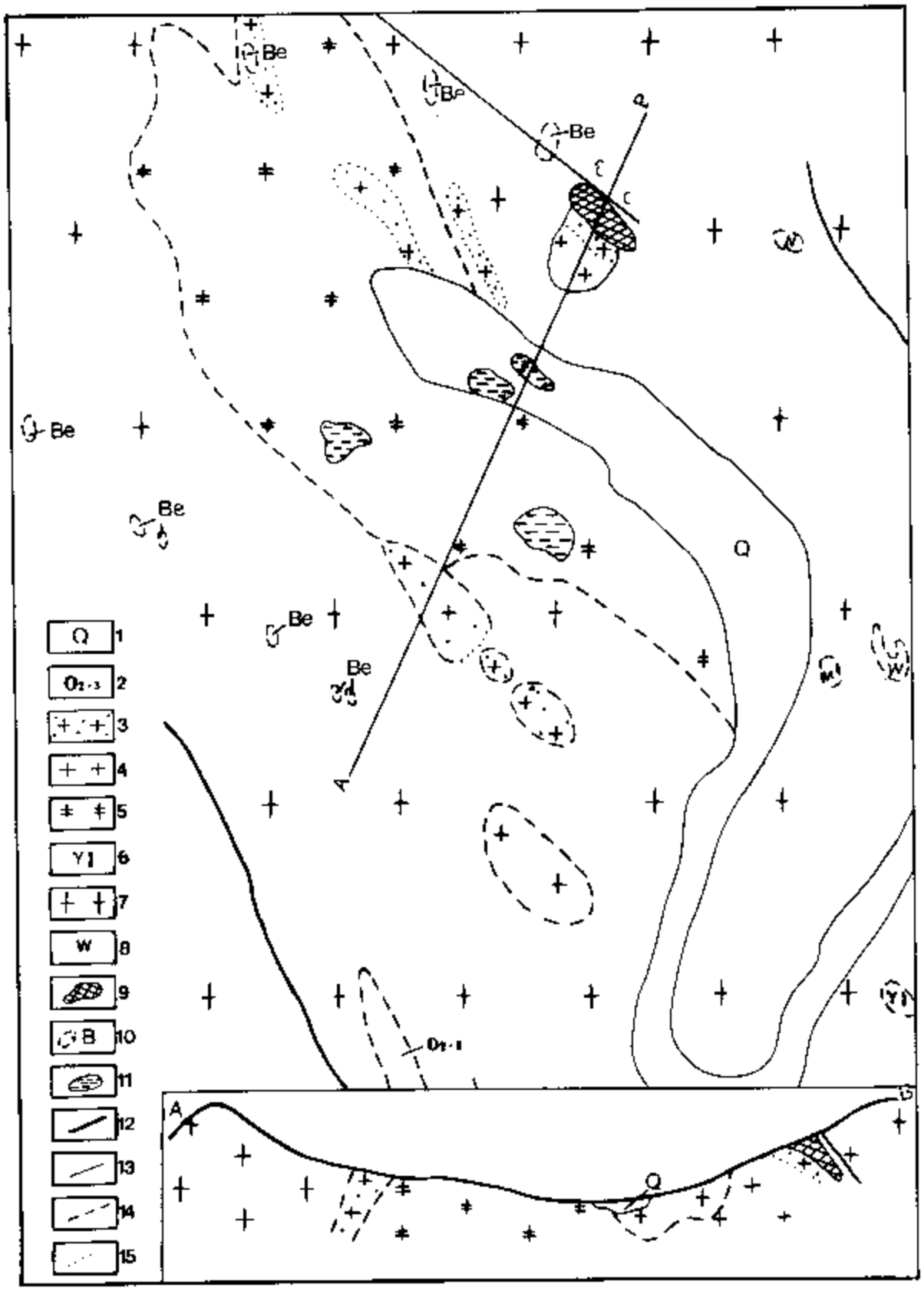
The exposed area of granite is generally very small. The albitized granite bearing beryl is located at the top of muscovite granite. It is the products of auto-metasomatism in the crystallization of muscovite granite. The two kinds of granite have a relation of successive teansition.

In the middle and upper parts of mineral-bearing granite, there are generally massives and veinules of greisenization, bearing beryls. Beryl-bearing quartz massives and veinules with rich content of beryl are the products of pneumatohenic-hydrothermal process after the evolution stages of granite deposit.

The greisen vein bearing beryl has a strike of 310-350,dip to east north,and the occurrence has the same direction as the longitutinal axis of granite body. The vein has a girdle structure, the inner part is massive quartz core and the out part is bery-quartz-muscovite. Now described respectively as following:

(1) Massive quartz core

The core is located in the centre of the vein. Most of them are in the swell part. The massive quartz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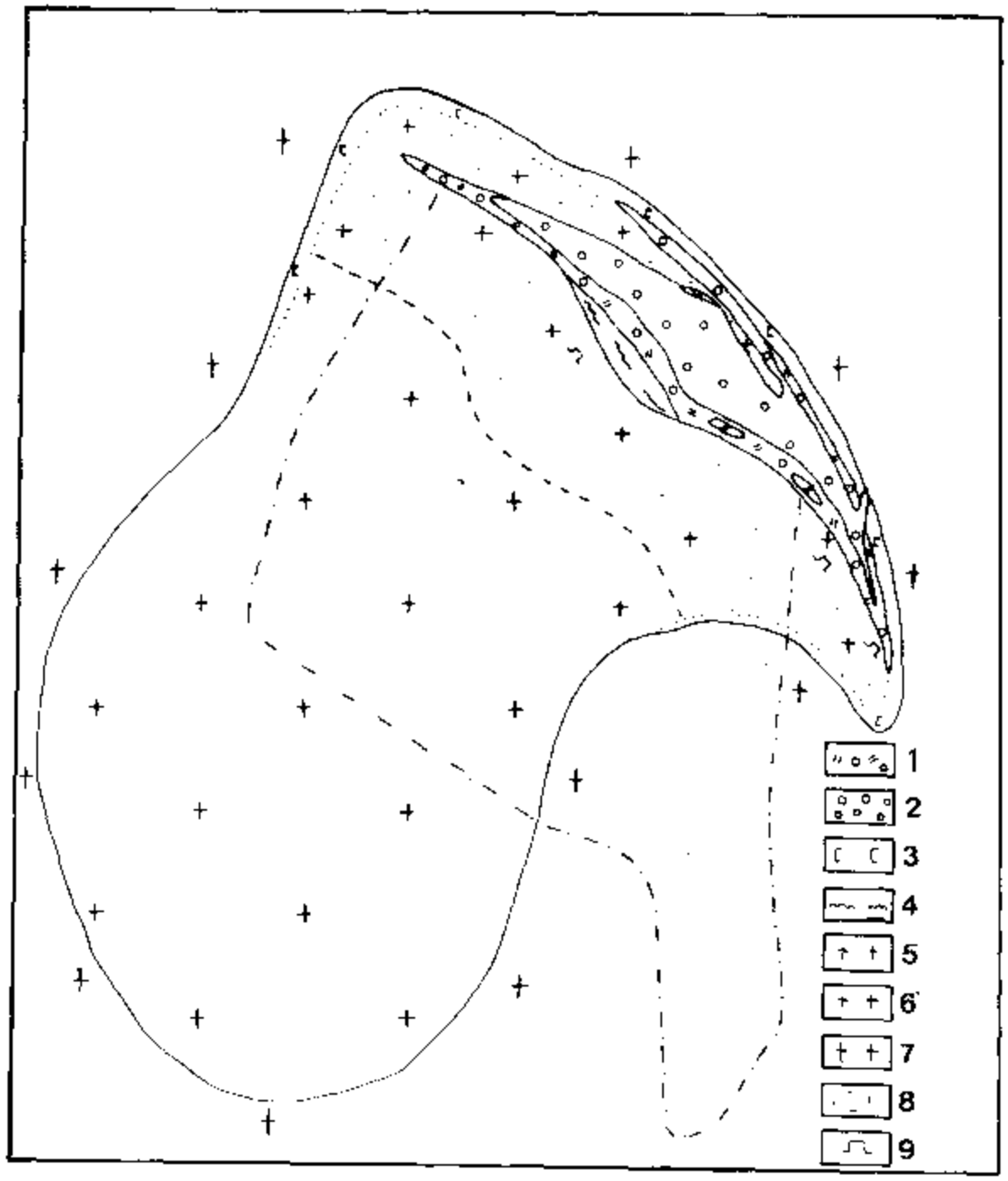


Key:

1. *Beryl-quartz-muscovite zone*
2. *Massive quartz core*
3. *Alteration zone with pegmatitic texture*
4. *Banded alteration zone*
5. *Alteration zone with granitic texture*
6. *Albitized muscovite granite*
7. *Biotite plagioclase granite*
8. *Emerald-bearing drift bed placer*
9. *Adit entrance*

Figure 63 A sketch map of beryl-bearing greisen vein

is of white colour, occupying more than 95%, and that in the margin is blackish grey, with length of 0.2–0.5m. There are more kinds of minerals, such as microcline, pyrite, beryl and less sphalerite and bismutholamprite. The beryl is light blue or light green in colour, with prismatic crystal shape. A few of beryls in studied zone, with beautiful colour and transparent, can be used as gems. The water bladder beryl discovered before is just in this zone.

(2) Beryl-quartz-muscovite zone

This zone, rich in beryls, surrounds the quartz core in swell part and narrow part, it departs from the

quartz core and inserts into the altered zone of beryllium-bearing granite, with clear contact boundary.

The main minerals are muscovite, quartz beryl, microcline, and secondly, pyrite, molybdenite, bismutholamprite, spessartine, albite, apatite, sphalerite galena and Nb-Ta iron ore, etc.

Texture and structure of the zone: Rock forming minerals are distributed at the top and base walls, with comb structure and vertical to the wall of vein. The structure becomes dispersion form toward the inner side of the vein, and gradually transformed into quartz core. In the centre of the vein massive quartz is mainly of smoky colour, with different thickness. The microcline distributed between muscovite and massive quartz is in small pieces. Beryls are concentrated in the zone as nests and veins, with the colours of light blue, light green to dark green, and dark blue. The crystals are of different size, most of them have the form of hexagonal prism, secondly of massive form. This zone is the main sector to produce gems. Aquamarine and normal beryl are produced in this zone.

2. Spacial Distribution of Greisen with Beryl

Greisen bearing beryl occurs in the top of granite containing beryllium. Judged from the occurrence, in primary stage of the formation of greisen bearing beryllium , the greisen appeared as massive, nest , belt and veinule, later it distributed along structural fractures as veins. This kind of greisenization is limited in albitized granite, which means that the formation of greisenization is associated with albitized granite.

Although this kind of deposit is less in number and small in scale , it has rich mineralization, so it is an important type of gem deposits.

IV. Metamorphic Deposits

There are a lot of gem and jade deposits formed by metamorphism. Among them, magma intruded into specific stratum, with hydrothermal metasomatism happened, forming magnesian skarns and calcareous skarns of contact metamorphism, in which some gems and jades of middle value are formed, such as andradite (Altai emerald), cinnamon stone, nephrite, and Kunlun jade, etc. In some deposits corundum (ruby, saphire) , almandine, spessartine, honey-wax jade, white jade, Tugu jade, aventurine and others are formed by regional metamorphism Now the metamorphic deposits discovered in Xinjiang are described respectively.

1. Gem and Jade Deposits Formed by Contact Metamorphism

Within this type of deposit there are skarn type and hydrothermal-metasomatic type. Different magma intruded into calcareous, magnesian carbonatites, forming different kind of gem and jade deposit. Their types are listed as follows:

(1) Skarn Type

There are important gems in skarn deposit, such as Altai emerald (green andradite) and cinnamoon stone, which are related to calcareous skarns that are produced in the flag marble in biotite - plagioclase-gneiss of Devonian (figf 64).

The mineral constituents are epidote, grossular calsite, tremolite-actionalite, scapolite axinite, diopside, quartz, microcline, plagioclase, manganese zoisite. Among them the grossular crystal druse has the forms of bag, small massive and lens, distributed discontinuously in the centre part of skarn, parallel to country rock. The solution forming skarn is considered to have relation to granite magma

source, which moved into calcareous carbonatite along faults, proceeding hydrothermal-metasomatic process to form the skarn.

(2) Contact Metasomatic Jasper Jade Deposits Formed by Intrusion of Ultrabasic Rocks

In the Tianshan Mt., the Arjin Mt. and other region, ultrabasic rock intruded into some specific stratum and brought the country rock into themselves as xenolith, and at the place near the contact, and contact-metasomatic process took place under proper geological condition, forming jasper jade deposit. This kind of jasper jade is of dark green or fresh green colour, with fine texture, but ununiformity.

In the Arjin mountains, nephrite is also found at some contacts of ultrabasic rocks and country rock. Its mineral constituents, physical and chemical properties resemble that of the Tianshan, and called 'Jinshan jade', of which the deposit genesis belongs the same type as that of jasper.

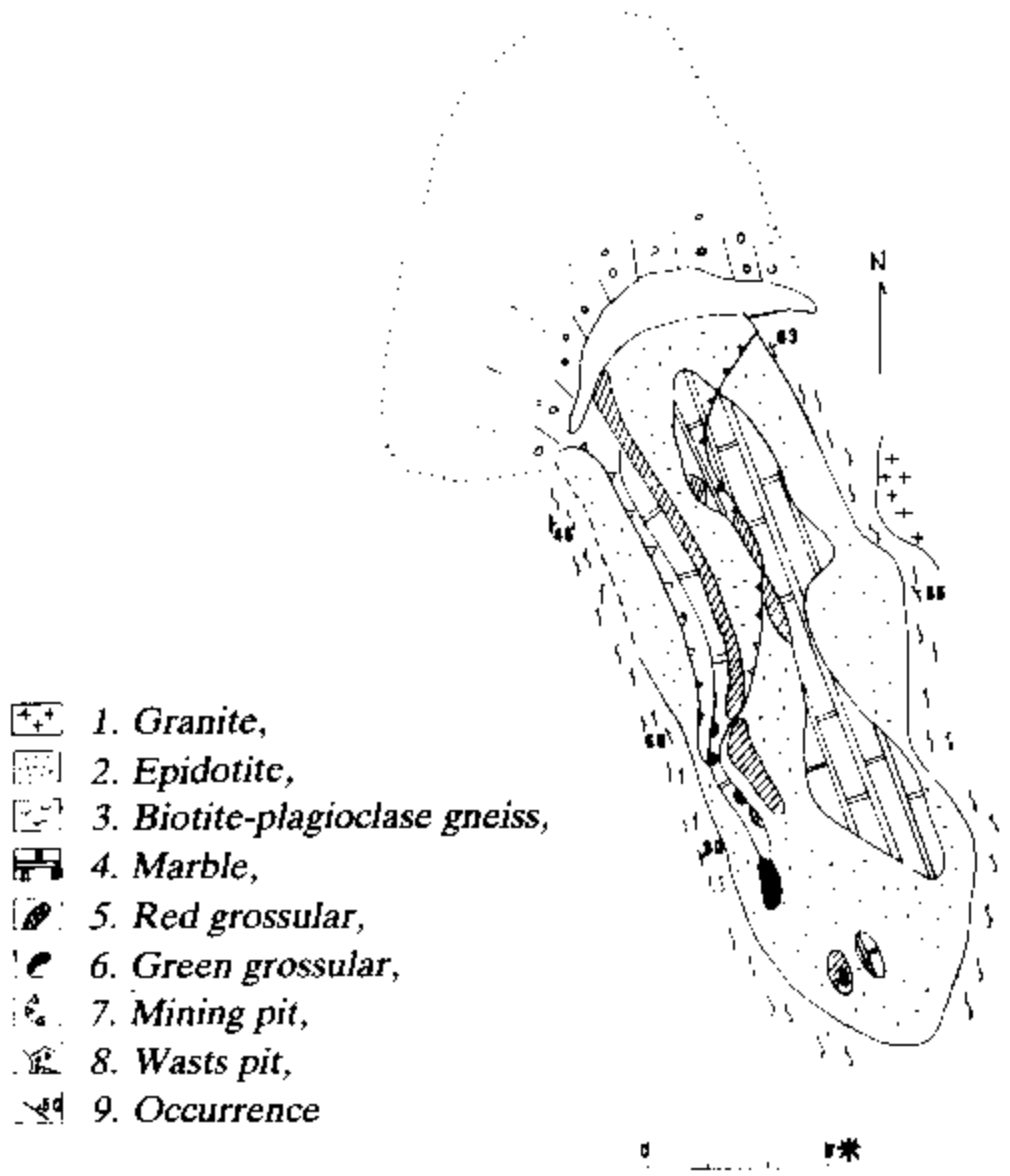


Figure 64. Distribution sketch of grossular ore bodys in some place of Xinjiang.

(3) Hotan Jade Formed by Contact Metasomatism of Dolomitic Carbonatite and Intermediate-acid intrusive rocks.

Hotan jade is distributed in the belt of the Kunlun mountains and the Arjin Shan mountains,with a linear arrangement of NW-EW-NE direction. The geologic characteristics: In the middle upwarped region of geosynclinal folded zone in the Kunlun Mt. and the fault block of the Arjin Mt, the distribution of mineralizations is generally no different to the structure line,all of them occurring near the great faults of metamorphic stratum of Brecambrian. And the nephrite deposits are formed in the contacts of magnesian carbonatite and intermediate-acid igneous rocks.

(4) Kunlun Jade Deposits of Contact Metamorphism

Kunlun jade is distributed in a region of the Kunlun Mt. and the Arjin Mt. , with the same occurrence as Hotan jade.

Kunlun jade is distributed near the Hotan jade deposits, and always associated with them. So, when prospecting or mining Hotan jade, Kunlun jade can be prospected or mined incidentally.

2. Gem and Jade Deposits of Regional Metamorphic Genesis

The gems and jades of regional metamorphic genesis in Xinjiang are ruby, sapphire, spessartine, white jade, honey-wax jade, aventurine,Tugu jade, etc. These gems and jades are formed basically under middle pressure and, according to temperature, can be divided into types of low, middle and high temperature, that correspond to green schist facies and spessartine amphibolite facies.

(1) Jade Deposits of Low Temperature Metamorphic Facies

The temperature of this kind of deposit is about 120-450°C, formed under the condition of regional metamorphism of green schist facies.. Those related to Katogeno-extradynamometamorphism and the metamorphism of low temperature stage are aventurine and Tugu jade.

i. Aventurine

Aventurine belongs to quartzite. Owing to bearing small amount of colourful minerals, the quartzite become aventurine with a soft and beautiful colour, and fine texture. Aventurine occurred in the geological times of Proterozoic and Devonian of the Paleozoic, with large distribution range and always had lens form. It was formed by marine chemical sediments through regional metamorphism.

ii. Tugu jade

Tugu jade occurs in upper Devonian stratum in the east part of Xinjiang.

The ore body is of lens form, and intercalated in metamorphosed sandstone and argillaceous slate. The primary rock is ferruginous silicotite, which forms Tugu jade of yellow clay colour through slight regional metamorphism and, at the surface, oxidation and leaching of water.

(2) Gem and Jade Deposits of Middle-high Temperature Metamorphic Facies:

In these deposits there are ruby, sapphire, almandine, wax-yellow jade, white jade, etc. Some gems may not have practical significance, but might become the sources of rich place. Both white jade and honey-wax jade occur in the metamorphic stratum of Cambrian.

i. Spessartine deposits

Spessartine is a representative mineral of middle, high metamorphic facies. In deep degree metamorphic region of Xinjang, such as Altai, middle Tianshan Mt.and the Kunlun Mt, etc. are distributed biotite-plagioclase-gneiss, schist, which always bear porphyroblast crystals of spessartine, some of them reach 5cm or more. These spessartines are of red and dark red colour, some with beautiful luster can be used as gems. But they are always closed in rocks so it is difficult to get complete crystals. A few of them departed from the mother rock by weathering and concentrated in the area where near the mother rock, forming spessartine placer.

ii. Ruby, sapphire mineralizations

Ruby and sapphire mineralizations in a place of Xinjiang occur in the stratum of Cambrian-Ordovician System, which belongs to the metamorphic sequence composed of gneiss, intercalated with marble of middle-deep regional metamorphism.The ore body is located in the out contact of granite diorite body of Variscian, with gems distributed in biotite plagioclase gneiss as single crystals.

The ore body occurs in lense form. There are several ore-bearing horizons, with base wall of marble and top wall of biotite garnet gneiss. The colours of them are light red and light blue, and inclusions of ilmenite and rutile are contained. The crystals are 1-2mm, with a lot of cracks, poor in quality, individuals reach the degree of gem. Placers, small in scale but rich in minerals, can be found near the slope wash.

iii. Honey-wax jade and white jade deposits

Honey-wax jade occurs in dolomitic marble of the Jixian System of the sub-stage of Sinian in the east part of Xinjiang. The ore body is of lens and massive forms. Honey-wax body has a relation of gradual change and transition to the dolomitic marble. It is clear that honey-wax jade is controlled by the lithological characters of stratum. Its dark yellow colour is attributed to the ferruginous materials which, after oxidation becomes yellowish brown iron oxides, are distributed in fractural places between dolomite granules. At the surface of ore body, the oxide colour is darker, and gradually becomes lighter in deep part underground. White jade is distributed in the marble formation of Jixian System of Sinian sub-stage, with large thickness and fine quality. Its formation is closely related to deep regional metamorphism.

V. Epigenetic Deposits

Epigene action has an important significance for the formation of gem and jade. For instance, ruby,sapphire,beryl, garnet, chrysocolla, turquoise and nephrite are from the rocks bearing them, which form all kinds of epigenetic deposits after having been cracked by weathering and leaching.

It is difficult to find better crystals in the primary rock of ruby and sapphire. But after weathering, valuable mono-crystals of them can be found. Thus ruby and sapphire placer can be found in weathering crust of biotite-plagioclase-gneiss, where the crust bears rich corundumites.

In the weathering zone of schist bearing garnets, more monocrystals of garnet occur in slope wash zone of weathering. Those garnets that have beautiful red colour and translucent property can be used as raw materials of gem. Lots of metamorphic rock distributed regions in Xinjiang are the main sources of garnet placers. The turquoise is distributed in oxidized zone of some polymetal deposits that contain copper. The mineralizations of turquoise in some place of Xinjiang occur in acid extrusive rock bearing copper, having been formed by weathering. In the sector where turquoise occurred, sponge-like quartz

veinlets are associated.The formation of turquoise is more complex and so is the chemical composition. It belongs to copper and aluminium parbighite, and can only occurs in crack-linear type of leached weathering crust containing copper sulfide, parbighite, and in the weathering crust bearing rich free silica and aluminium oxide. Thus, the turquoise has close relation to the ancient weathering crust of aluminosilicatite containing copper and phosphorus.

Nephrite,through weathering, glacial process, and scouring of flood, was brought to piedmont alluvial region, where egg-form Zi jade (Hotan jade, Jasper) can be found.

Beryl placer occurs at the slope of a beryl pneumatolytic-hydrothermal beryllium deposit in a place. It belongs to placers of slope wash formed by glacial erosion, and is connected with pneumatalytic-hydrothermal deposit of endogenetic type. Its constituents are basically of no difference with the primary rock at the upper reaches, and are mainly granitoids and greisen containing beryl. According to constituents and grandularlity, accumulations can be divided into three formations:

i. Rubble formation at surface mainly consists of biotite-plagio-clase-granite, muscovite-biotite-granite, altered granite and greisen bearing beryl. The diameter of the rubble is 0.5-3m. The primary rock bearing beryl occurs together with other kinds of rock, no sorting.

ii. Sand and clay formation in middle, mainly consists of clay and sands, with 20% granite and quartz pieces of discontinuous distribution, and with less beryl,hence a secondary ore-bearing formation.

iii. The lower is a formation of sands, caly, pieces of stone and rubbles. It is main ore bearing formation. The sediments are mainly granite and ore bearing vein stone from upper reaches. The base rock of them is muscovite-biotite-granite. The tonner of beryl is of great change. Most of beryl are massive, part of them prismatic. Individual crystals reach 20cm. A small amount beryls are in this formation.

Section Three. The Direction of Prospecting Gem and Jade Deposits

Summing up,the geological characteristics of occurrence of gems and jades have showed that there are many kinds of gems and jades, and lots of various kinds of deposits of gem and jade in Xinjiang. And there is regularity to prospect them. Now, based on the geological characteristic of different regions in Xinjiang, we put forward some primary informations to prospect gems and jades, for discussion.

(1) Granite pegmatite are well developed in some regions of Xinjiang.Especially in granite pegmatites of late stage of Variscian, there are lots of gems and jades produced, such as aquamarine, jasper, rose quartz, amazonite, topaz, lilac perple, purple apatite, noble spodumene, various quartz, soft water amethyst, etc. Rare metal pegmatite , muscovite pegmatite, miarolitec pegmatite and 'empty bag' type pegmatite are the main place to prospect those gems and jades.

(2) In the ultrabasic rock body of Variscian in the Tianshan, if there are xenoliths of country rock, and with contact metasomatism happened, at which is the place to prospect jasper. There are ultrabasic rocks producing jade that resembles jasper, which can be used as a clue for prospecting Jinshan jade. There are lots of ultrabasic bodies in Junggar Region, where, if proper geological condition exists, gems

and jades such as noble olivine, demantoid, serpentine jade,Kunlun jade;Dushan jade and so on can be prospected for.

(3) In the Kunlun Mt., the Arjin Mt. and somewhere near the contact of magnesian carbonatite and intermediate-acid intrusive rock in metamorphic stratum of Cambrian, is an important sector to prospect Hotan jade . The river reaches and gobi at piedmont of the mountains are main places to find Hotan jade. Kunlun jade occurs near the deposit of Hotan jade.

(4) At the margin of Tarim Basin, Kimberlite has been found, in which diamonds that may reach gem grade might be found in the near future.

(5) Corundum has been found in the plagioclase-gniess of pluton-metamorphism in a place of Xinjiang, some corundum crystals reachs the grade of gems. We consider that ruby and nephrite should be prospected continuously in the region with same geological conditions.

(6) Beryl might be found in greisen formed in pneumatolytic-hydrothermal process and related to the granite of Yanshan period. Skarn is the main target to prospect grossular and cinnamon stone.

(7) In the region where volcanic lava well developed, agate green and glass jade can be found. East Junggar is a promising region.

(8) The formation of Jixian system of Sinian sub-stage, is a main horizon to prospect wax-yellow jade and white jade.

Appendix: Major consulting document – The Chinese – English names of Xinjiang gems and jades

Mineralogical and Petrological Name	Name in English	Craftwork Name	Name in English
金剛石	Diamond	鑽　　石	Diamond
剛　　玉	Corundum	紅寶石	Ruby
		藍寶石	Sapphire
石榴石	Garnets	紫牙烏	Garnet
		翠榴石	Demantoid
		肉桂石	Cinnamon Stone
		阿爾泰祖母綠（加利福尼亞石）	Altai Emerald (Californite)
		錳鋁榴石	Spessartite
黃　　玉	Topaz	蜜黃色黃晶	Bee-Yellow Topaz
		玫瑰色黃晶	Rose Topaz
		藍色黃晶	Blue Topaz
綠柱石	Beryl	海藍寶石貓眼石	Aquamarine Cat's eye
		海藍寶石	Aquamarine
		綠色綠寶石	Green Beryl
		金黃色綠寶石	Golden Beryl
		純綠寶石	Colourless Beryl
		水胆綠寶石	Water Bladder Beryl
		玫瑰色綠寶石	Rose Beryl
鋰輝石	Spodumene	翠綠貴鋰輝石	Emerald-green Precious Spodumene
		黃綠貴鋰輝石	Yellowish-green Precious Spodumene
電氣石	Tourmaline	碧　　璽	Tourmaline
紅電氣石	Red Tourmaline	紅碧璽	Rubellite
綠電氣石	Green Tourmaline	綠碧璽	Green Tourmaline
藍電氣石	Blue Tourmaline	藍碧璽	Indicolite

黃電氣石	Yellow Tourmaline	黃碧璽	Yellow Tourmaline
紫電氣石	Purple Tourmaline	紫碧璽	Purple Tourmaline
黑電氣石	Black Tourmaline	黑碧璽	Black Tourmaline (Schorl)
磷灰石	Apatite	紫磷灰石	Purple Apatite
石英	Quartz	紫晶	Amethyst
		水晶	Rock Crystal
		茶晶	Tea-crystal
		烟晶	Smoky Quartz
		鬃晶	Bristle Crystal
		髮晶	Hair Crystal
		黃水晶	Citrine
		芙蓉石	Rose Quartz
微斜長石	Microcline	天河石	Amazonite
鋯石	Zircon	風信子石	Zircon
螢石	Fluorite	軟水紫晶	Fluorite
軟玉	Nephrite	羊脂玉	Sheep Fat-colour Jade
		白玉	White Jade
		青玉	Green Jade
		青白玉	Green White Jade
		墨玉	Black Jade
		糖玉	Brown Sugar Jade
		黃玉	Yellow Jade
		黑白玉	Black and White Jade
		碧玉	Jasper
		金山玉	Arjin-shan Jade
蛇紋岩	Serpentine	崑崙玉	Kunlun Jade
		新坑白玉	New Pit White Jade
		蛇綠玉	Serpent-green Jade
硅板岩	Silicious Slate	土古玉	Tugu(Yellow Clay)Jade.
次生石英岩	Secondary Quartzite	綠東陵石	Green Aventurine

次生石英岩	Secondary Quartzite	肉東陵石	Yellowish-pink Aventurine
		白東陵石	White Aventurine
		京白玉	White Secondary Quartzite
綠松石	Turquoise	松石（土耳其玉）	Turquoise
玉髓	Chalcedony	白瑪瑙	White Agate
		瑪瑙	Agate
		紅瑪瑙	Carnelian
		黑瑪瑙	Black Agate
		紫瑪瑙	Purple Agate
		鬼面青	Ghost Face Grey Agate
		藍瑪瑙	Blue Agate
		黃瑪瑙	Yellow Agate
		苔紋瑪瑙	Moss Agate
		纏絲瑪瑙	Sardonyx
		縞瑪瑙	Onyx Agate
		截子瑪瑙	Lace Agate
		合子瑪瑙	White-thread Black Agate
		竹葉瑪瑙	Bamboo Leaf Agate
		城背瑪瑙	Firewood Agate
方鈉石	Sodalite	藍紋石	Sodalite
孔雀石	Malachite	石綠	Malachite
硅孔雀石	Chrysocolla	硅孔雀石	Chrysocolla
斜長岩	Anorthosite	獨山玉	Dushan Jade
斜長石透閃石岩	Plagioclase-tremolite Rock	特斯翠玉	Tekes Green Jade
白雲石大理岩	Dolomite Marble	蜜蠟黃玉	Wax-yellow Jade
鐵碧玉	Jaspilitejaspilyte	羊肝石	Sheep Liver-colour Stone
小文象偉晶岩	Minor Graphic Pegmatite	小文象石	Minor Graphic Stone
黑曜岩	Obsidian	玻璃玉	Glass Jade
鋰雲母岩	Lepidolite	丁香紫	Lilac Purple Jade

EDITORIAL NOTE

This book, an English translation of Xinjiang Gems And Jades, appears before our readers now. This is another mutual labourious work after the Chinese version which has been in the collaboration between the Xinjiang People's Publishing House and Ridgeville Ltd. Jewellery Magazine Publisher, Hong Kong.

Xinjiang's Gems And Jades is a volumn of overall introduction , at homc and abroad, of the rich mineral deposits of gems and jades in Xinjiang, which has the reputation of "the State of Gold and Jadc", being famous in China.This book also gives an all-round introduction of the resources of the various mineral commodities of 27 types of gems and 44 types of jades, which have been proved and utilized in Xinjiang, including the physical propertics, the valuc of craftsmanship, geological characteristics and the prospecting of quarrying, having the important practicable value for the professional technology. This book not only renders an exposition of the characteristics of the gems and jades as mineral commodities, rocks and prospecting geological, but renders a discussion of the handicraft material and in distinction from false from the view of craftsmanship as well. Thus, it will enable those scientist, technologists and specialists being engaged in the study of gems and jades, and those commercial circles of jewellery to acquire a better understanding of the resources, the assessment of exploitation and utilization of gems and jades produced in Xinjiang so as to promote the international exchange in the jewellery circles. Moreover, it provide for the outside partners who have the interest to invest or in the join venture in this field with the source material and information for the research work. That is why the aim of this book has been translated and the English version has been published the world over.

Ridgeville Ltd. Jewellery Magazine Publisher, Hong Kong has rendered its cordial collaboration and assistance to the translation work of the English version of Xinjiang's Gems And Jades. Besides, we have organized some research fellows for gems and jades, the geological and mineral engineers and technologists, the personel of the scientific information and English teachers, in coordination of the translation and proof-reading work. Owing to the book, being the first edition introducing the gem and jadc resources in a region, being very professional and technological, involving wide spread knowledge and the problems about the craftsmanship, being lack of unified reasonable final conclusion so far in the world over the denomination of the terms in this field being different, the translation work must have had some mistakes and errors and the expressions in English not so proper and perfect. We sincerely hope that we will gain the understanding from the experts and our readers. We arc, therefore, deeply grateful to and welcome, anyone who would criticize and give us correction from far and near.

Liang Jiaqi of the Language Department of Xinjiang Education College and adviser of Xinjiang Economic and Technical Information Research Institute, Cao Aiguo of Geological Department of Xinjiang Engineering Institute and Dai Jianguo of the Information Office of Xinjiang Geology Research

Institute have made much more contribution in the translation and proof-reading work. We must emphasize that the final work of the book was chiefly completed by them. Additional thanks for assistance and the translation and proof-reading work are due Wang Jiashu of the information Institute of Chinese Academy of Geology, Luan Bingao, the expert of China Gems and Materials Co., Associate Prof. Gao Dengzhang, and Lecturer Sun Jinyuan of the Foreign Language Department of Xinjiang University, Zhou Jin of Xinjiang Petrolium Institute.

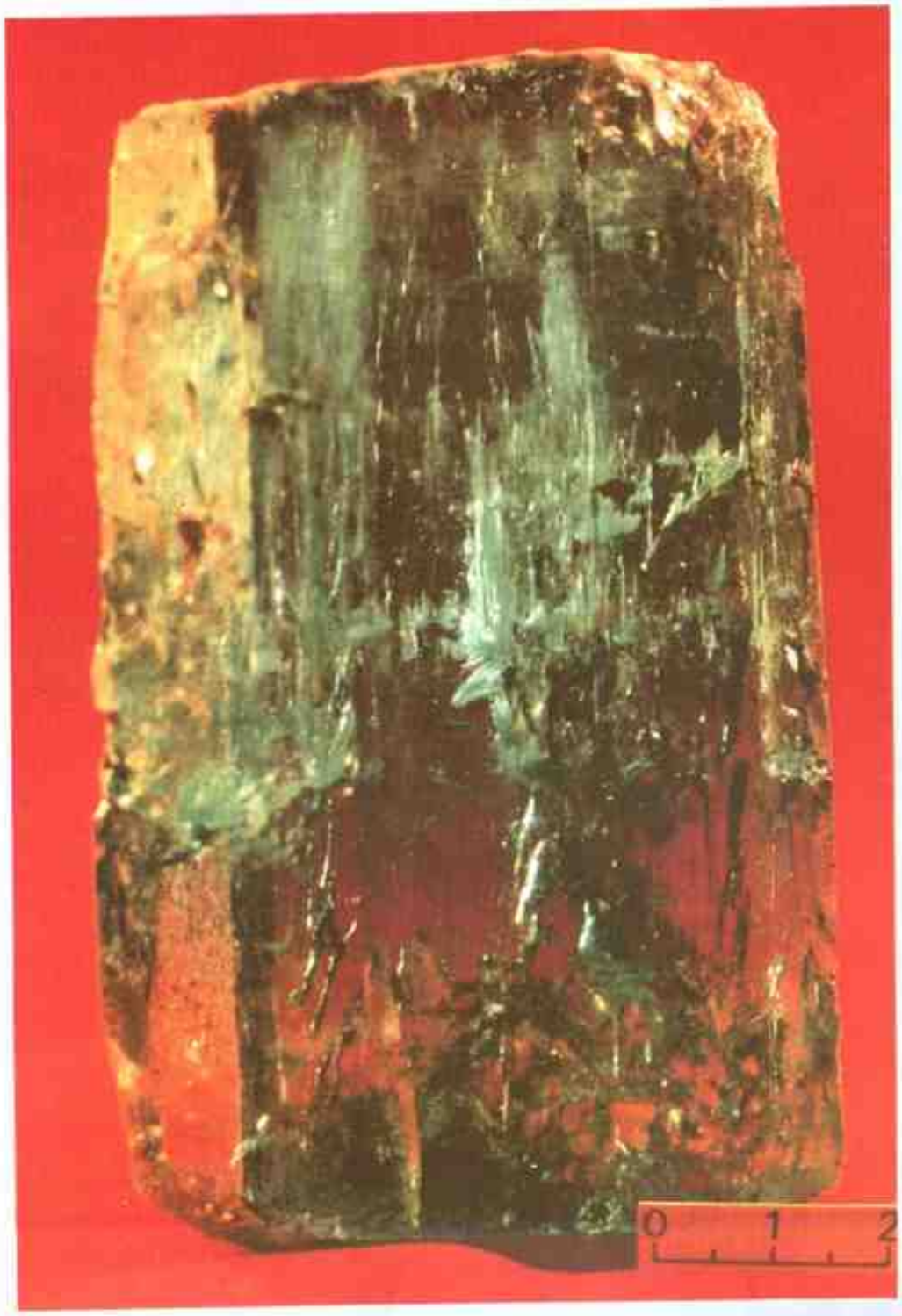
Xinjiang People's Publishing House.





彩圖 1　綠寶石（上）
Beryl

彩圖 2　綠寶石（下）
Beryl





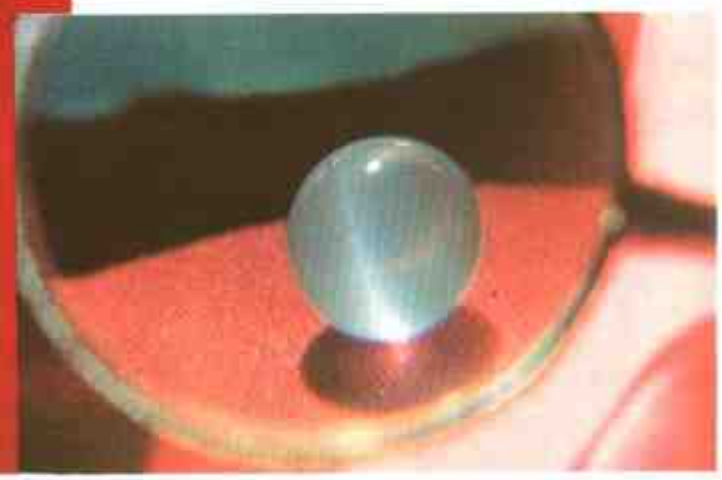
彩圖 3　綠色綠寶石(上)
Green Beryl

彩圖 4　綠寶石 (下)
Beryl

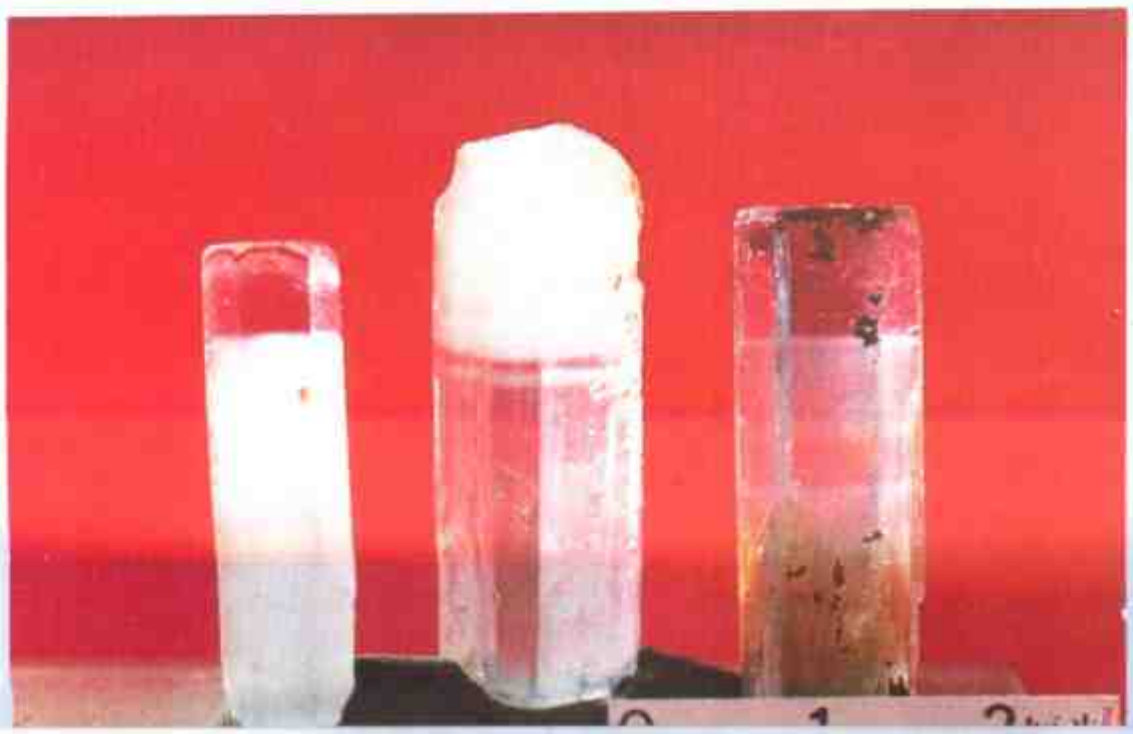


彩圖 5　海藍寶石
Aquamarine









彩圖 6　海藍寶石貓眼石(上)
Aquamarine Cat's eye

彩圖 7　金黃色綠寶石(中)
Golden Beryl

彩圖 8　純綠寶石(下)
Colourless Beryl





彩圖9　"西瓜"電氣石(上)
"Watermelon" Tourmaline

彩圖10　紅、綠碧璽(下)
Red & Green Tourmalines



彩圖11　藍綠碧璽及串色碧璽(左)
Blue-green & vari-colored Tourmalines

彩圖12　綠碧璽及戒面(右)
Green Tourmaline and ring facets





彩圖13　黑碧璽（左上）
Black Tourmaline

彩圖14　錳鋁榴石及戒面（下）
Spessartine and ring facets



彩圖15　紅碧璽、串色碧璽與
白色綠柱石共生（右）
Red & vari-colored
Tourmaline intergrowth
with White Beryl











彩圖16　鈣鋁榴石（左上）
Grossularite

彩圖17　阿爾泰祖母綠及戒面（右中）
Altai Emerald

彩圖18　肉桂石（右下）
Cinnamon Stone



彩圖19　紅寶石(右)
Ruby

彩圖20　含剛玉黑雲母斜長片麻岩(下)
Biotite-plagioclase gneiss with Corundum







彩圖21　黃綠色貴鋰輝石(上)
Yellowish-green precious Spodumene

彩圖22　綠色貴鋰輝石(左下)
Green precious Spodumene





彩圖23、24 紫磷灰石
Purple Apatite



彩圖25　黃晶
Topaz

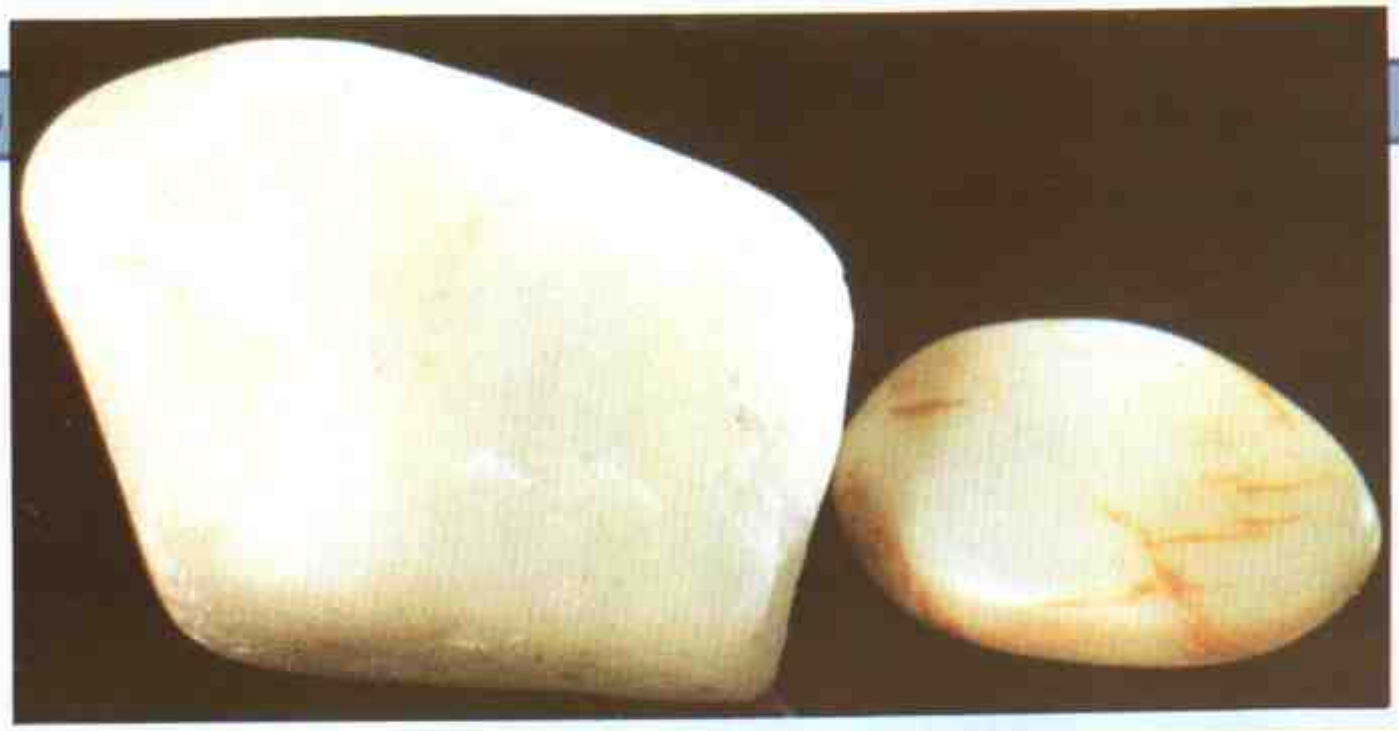


彩圖26　天河石（亞馬遜石）
Amazonite



彩圖27　軟玉－大禹治水圖山子（景）（引自〈故宮博物院藏工藝品選〉）

Nephrite carving – mountains-and-waters view of "Yu the Great, Tamer of floods" (quote from The Palace Museum handicraft article sections.)



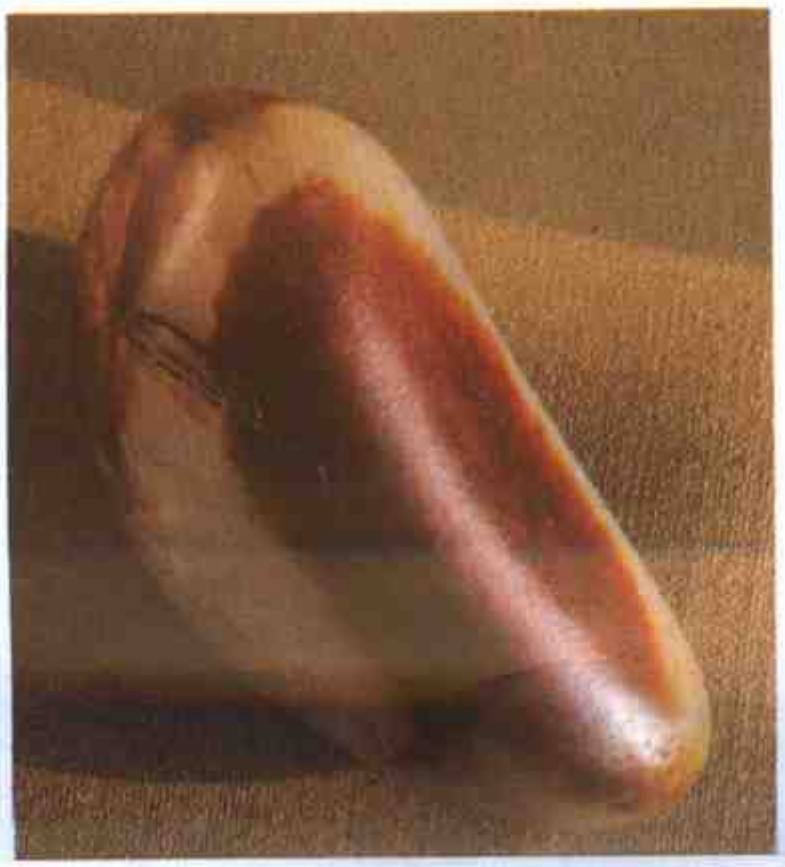


彩圖28　羊脂玉（右上）
Sheep fat colour Jade

彩圖29　墨玉（黑色部分）（右中）
Black Jade (black part)

彩圖30　青玉（右下）
Green Jade

彩圖31　糖玉（下）
Brown Sugar Jade







彩圖32　玉帶(明代)(上)
Jade Belt (Ming Dynasty)

彩圖33　雙龍耳玉杯(清代)(右下)
Jade cup with twin-dragon handles (Qing Dynasty)







彩圖34　雙桃玉洗(清代)(上)
Twin-peach washer made of Imperial Jade (Qing Dynasty)

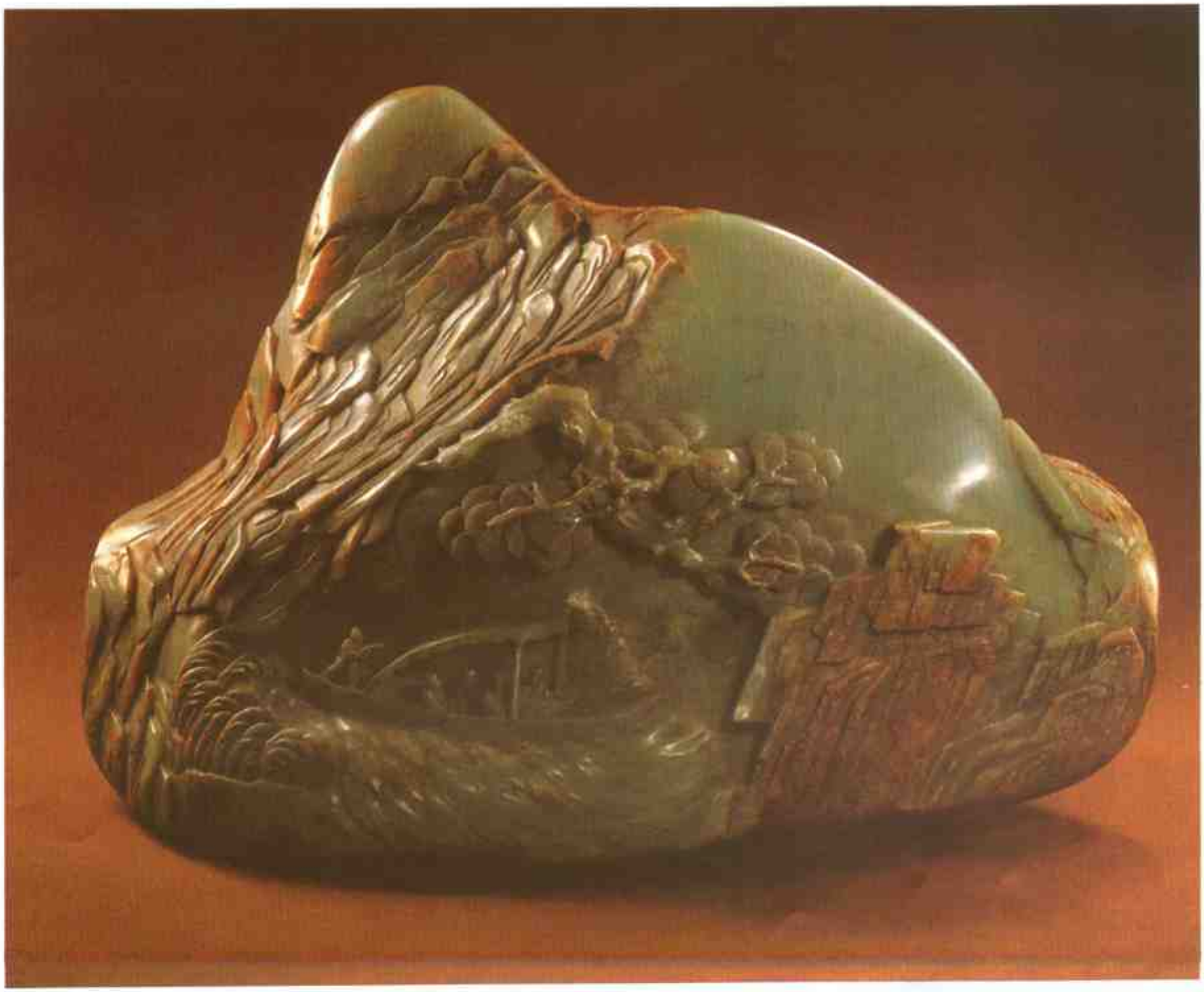
彩圖35　蟠紋桃花洗(清代)(右)
Jade Washer in the shape of Peach (Qing Dynasty)





彩圖36　雙龍玉帶扣(清代)(上)
Jade buckle with Twin-dragon (Qing Dynasty)

彩圖37　赤壁泛舟圖嶼(清代)(右)
"Boat sailing at the Red Cliff" (Qing Dynesty)







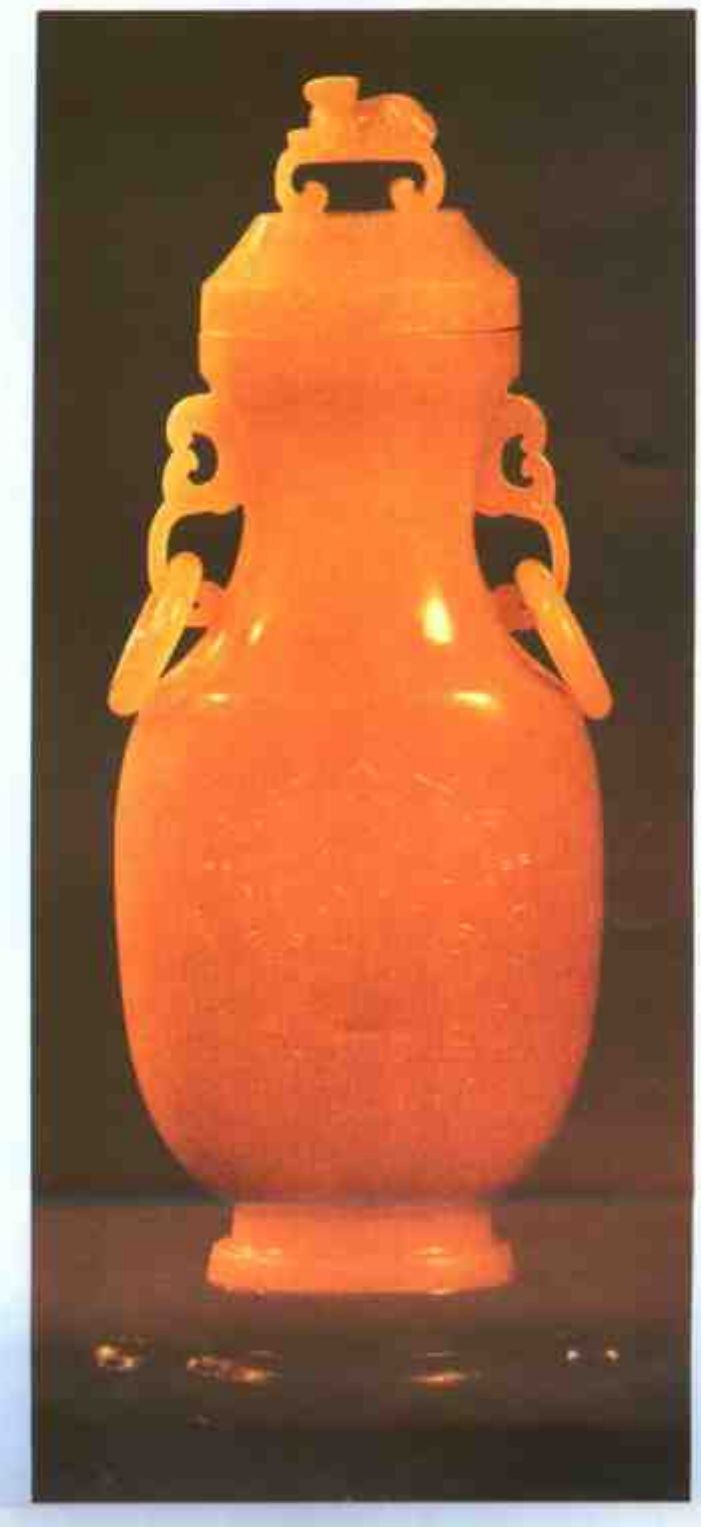
彩圖38　墨玉雙馬（引自〈中國礦物〉）（左上）
Twin-horse made of Black Jade (Quote from the "China Mineral")

彩圖39　羊脂玉雙鹿（引自〈中國礦物〉）（左下）
Sheep fat colour Jade Twin-deer (Quote from the "China Mineral")

彩圖40　青白玉馱龍獻璧（右下）
"Camel & Dragon present a Treasure" made of Greenish White Jade



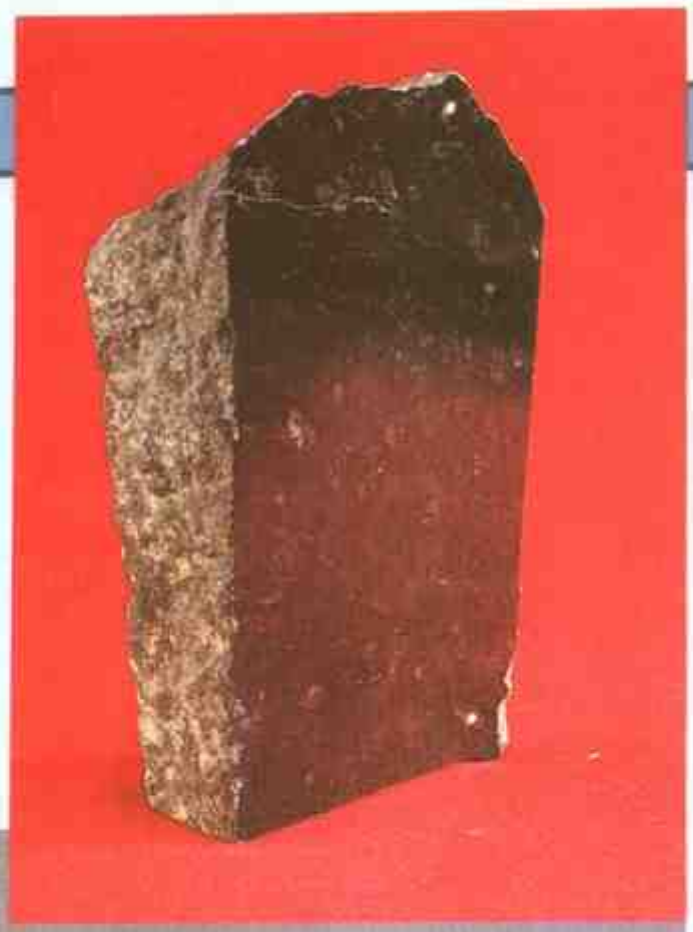




彩圖41　青玉五環爐（右上）
Green Jade incense burner with 5 loose rings

彩圖42　黃玉瓶（引自<故宮博物院藏工藝品選>）（左下）
Yellow Jade bottle (quote from "The Palace Museum "handicraft article selections.")

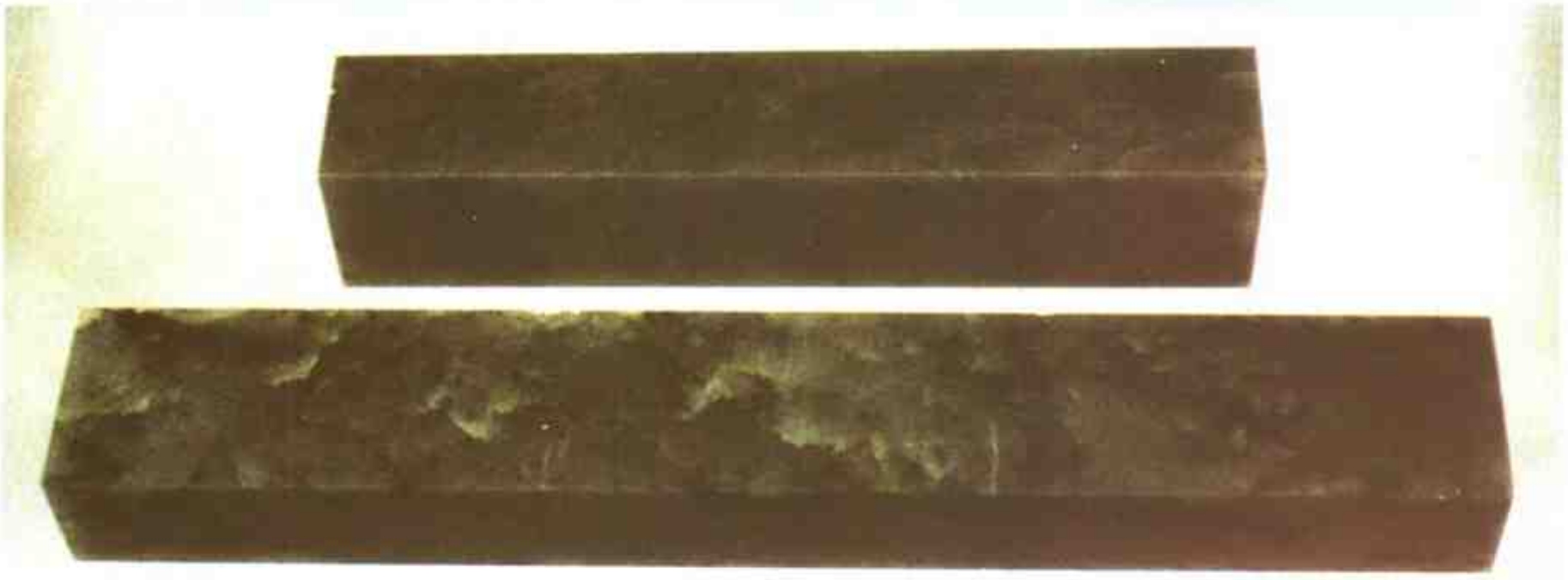
彩圖43　金山玉(右上)
Arjin - Shan Jade
彩圖44　碧玉（右下）
Jasper
彩圖45　碧玉（下）
Jasper



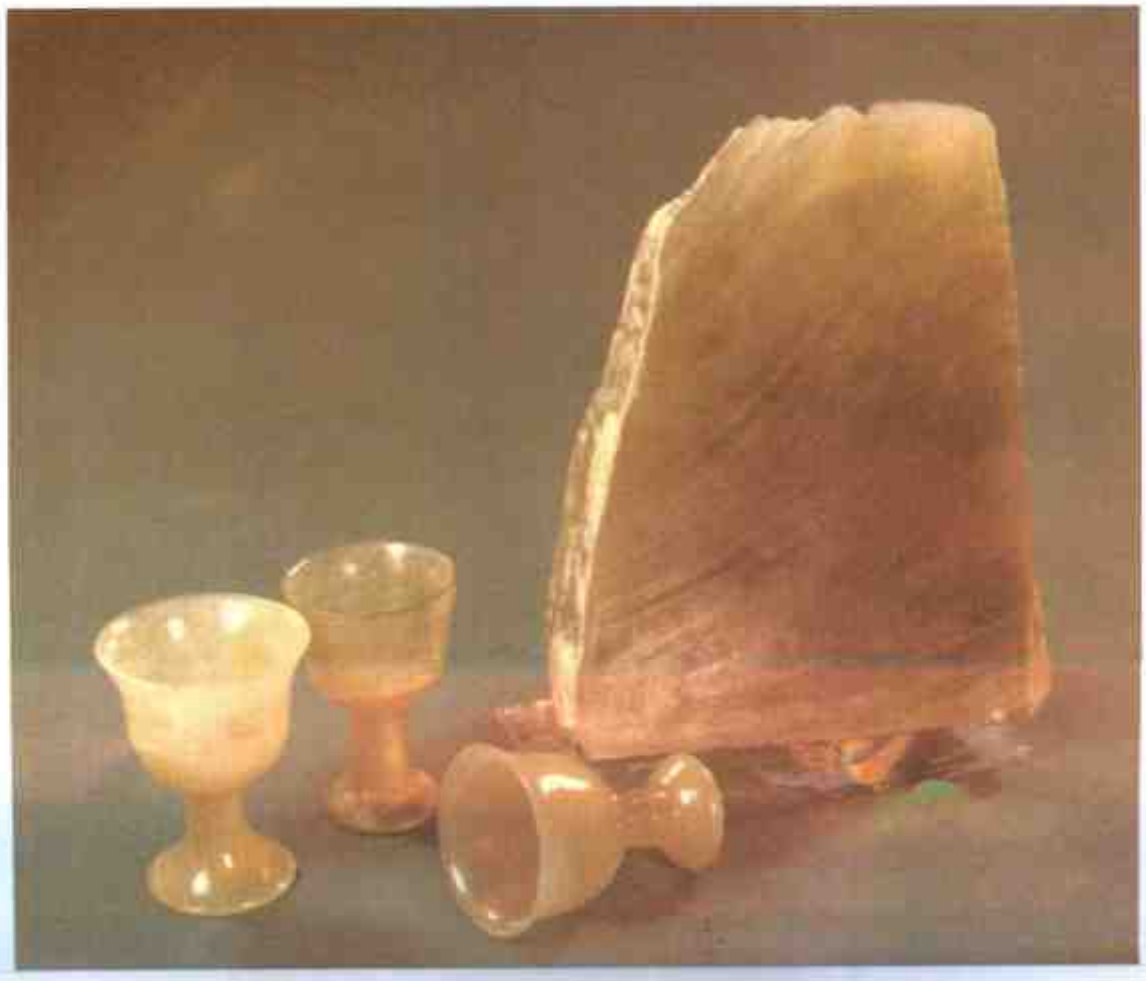












彩圖46　碧玉羅漢面海碗（左上）
Jasper great bower with Luo-Han face

彩圖47　碧玉鎮尺（左下）
Jasper Paperweight

彩圖48　崑崙玉哪吒鬧海（右上）
Kunlun Jade – "Ne-Zha rioting the sea"

彩圖49　崑崙玉及酒杯（右下）
Kunlun Jade and cups

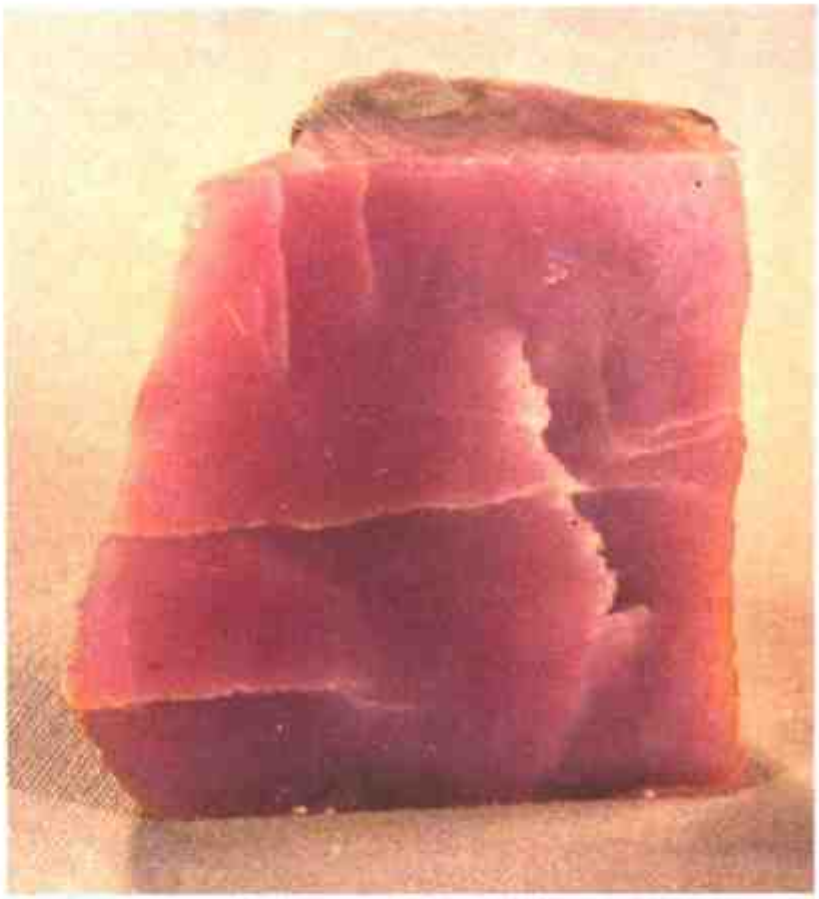




彩圖50　丁香紫李白醉酒（上）
Lilac purple Jade – Drunk Li Bai

彩圖51　丁香紫六環象爐（左下）
Lilac purple Jade incense burner decorated with elephant design

彩圖52　丁香紫塔爐(右)
Lilac purple Jade
"Pagoda-incense burner"
彩圖53　丁香紫(下)
Lilac purple Jade







彩圖54　芙蓉石(左上)
Rose Quartz

彩圖55　茶晶(左下)
Tea-crystal





彩圖56　水晶晶簇(右)
Rock Crystal druse







彩圖57　髮晶光面(左上)
Hair Crystal
polished surface

彩圖58　髮晶熊(左中)
Hair crystal bear

彩圖59　紅髮晶(左下)
Red Hair Crystal



彩圖60　髮晶及戒面
Hair Crystal
and ring facets

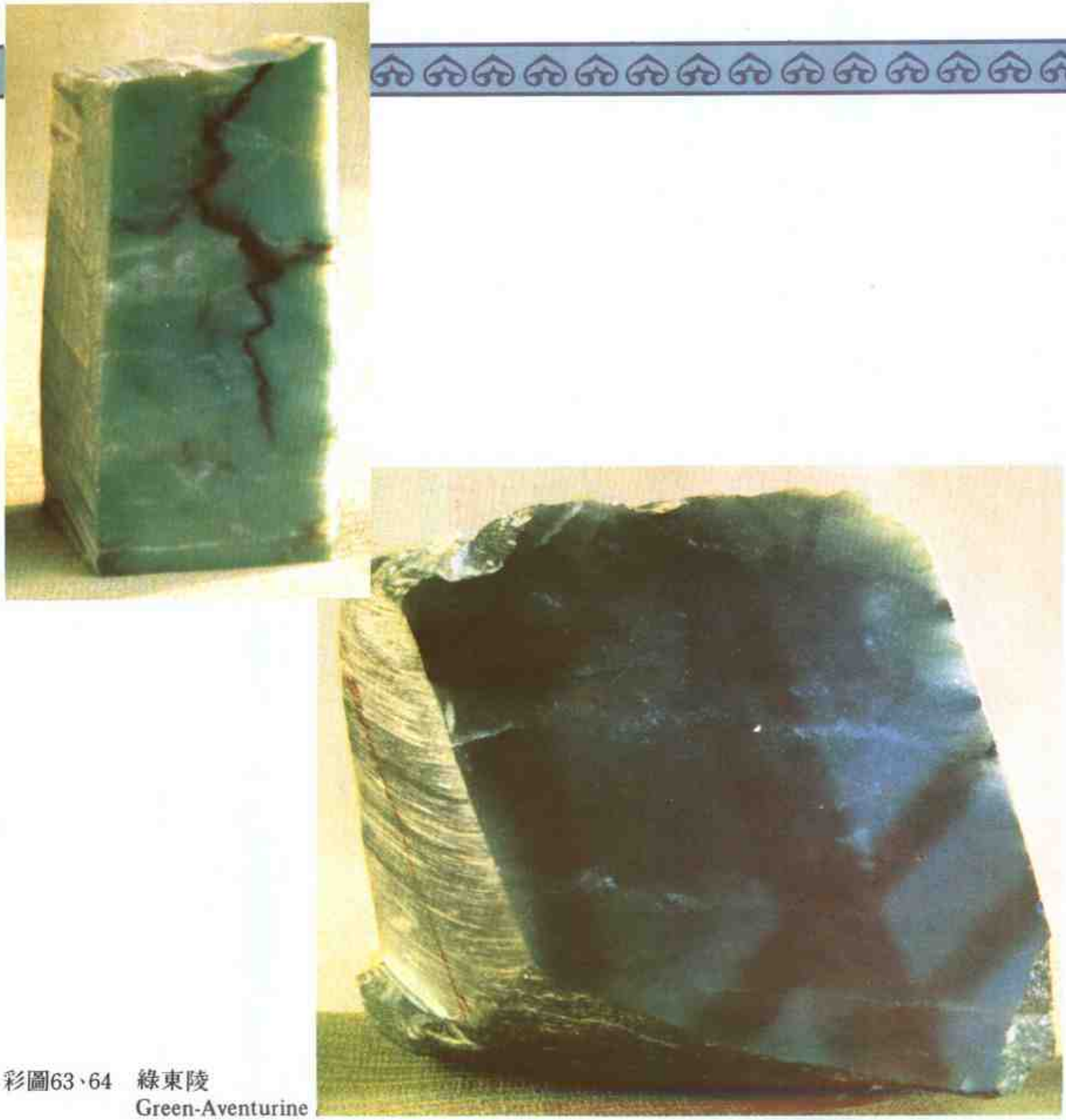






彩圖61　紫晶及戒面(上)
Amethyst and ring facets

彩圖62　紫晶(下)
Amethyst



彩圖63、64　綠東陵
Green-Aventurine



彩圖65　瑪瑙
Agate

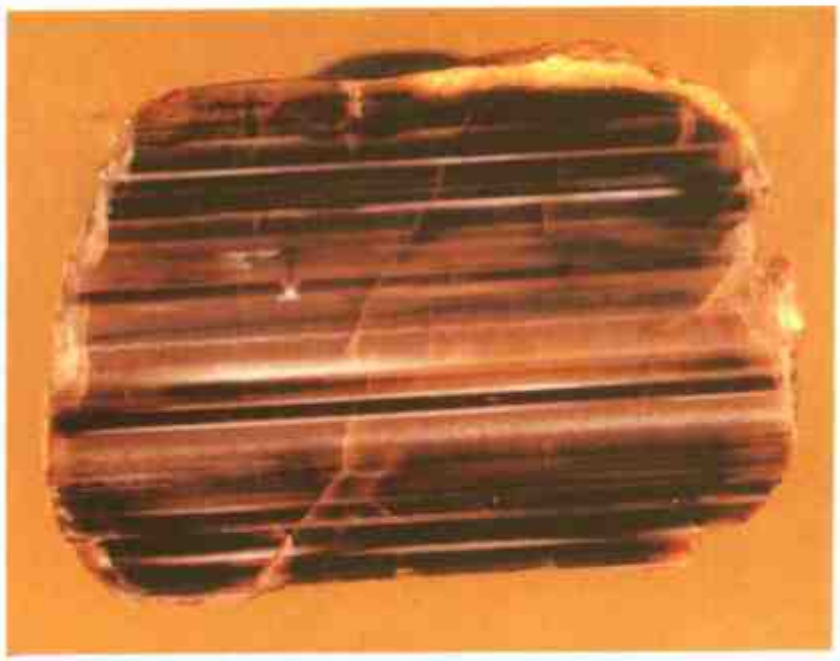


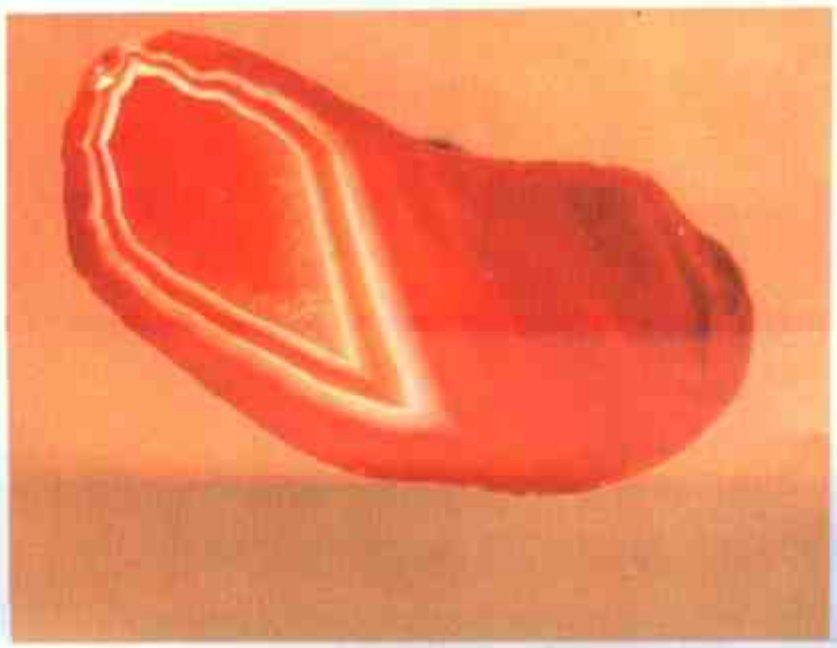


彩圖66、67　柴狀瑪瑙
Firewood
Agate









彩圖68　白瑪瑙（右上）
White Agate

彩圖69　縞瑪瑙（右下）
Onyx Agate

彩圖70　截子瑪瑙（左上）
Lace Agate

彩圖71　火炬瑪瑙（左下）
Torch Agate







彩圖72、73、74　閃光瑪瑙
Schiller Agate





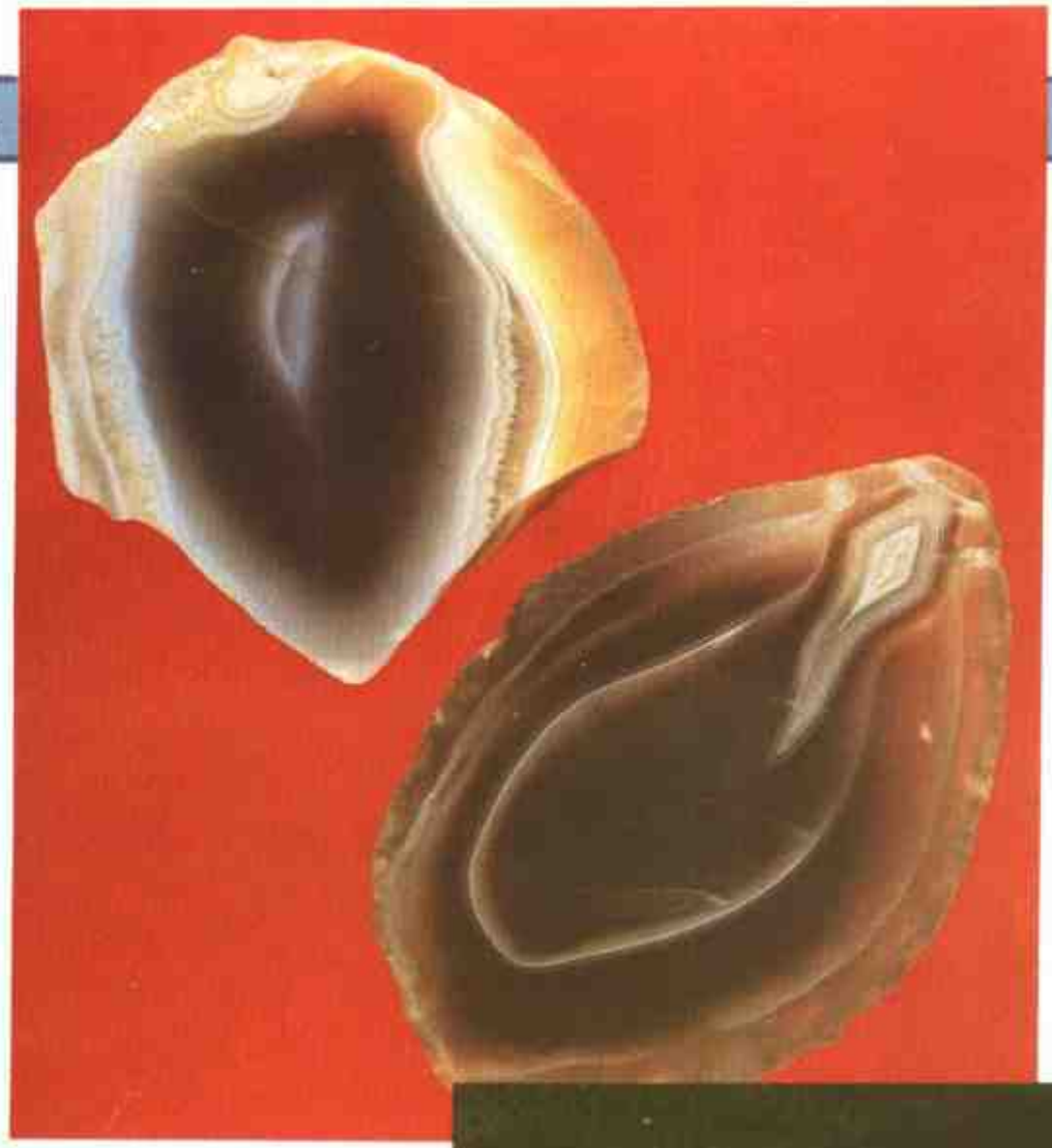
彩圖75　砂心瑪瑙（上）
Sand Core Agate

彩圖76　瑪瑙（下）
Agate





彩圖77、78　瑪瑙
Agate





彩圖79　瑪瑙
Agate

彩圖80　瑪瑙
Agate





彩圖81　蜜蠟黃玉象（上）
Wax-yellow Jade elephant

彩圖82　蜜蠟黃玉（下）
Wax-yellow Jade











彩圖83　蜜蠟黃玉飛天(左上)
"Flying Apsaras" made of Wax-yellow Jade

彩圖84　蜜蠟黃玉番佛(左中)
The Buddha made of Wax-yellow Jade

彩圖85　蜜蠟黃玉龜龍獻璧(左下)
Wax-yellow Jade carving – "Turtle & dragon present a Treasure".

彩圖86　蜜蠟黃玉爐(右上)
Wax-yellow Jade incense burner

彩圖87　蜜蠟黃玉方鼎(右下)
Wax-yellow Jade quadripod





彩圖88　蜜蠟黃玉仕女（上）
Female Figurine, with Wax-yellow Jade

彩圖89　蜜蠟黃玉鹿（下）
Wax-yellow Jade Deer



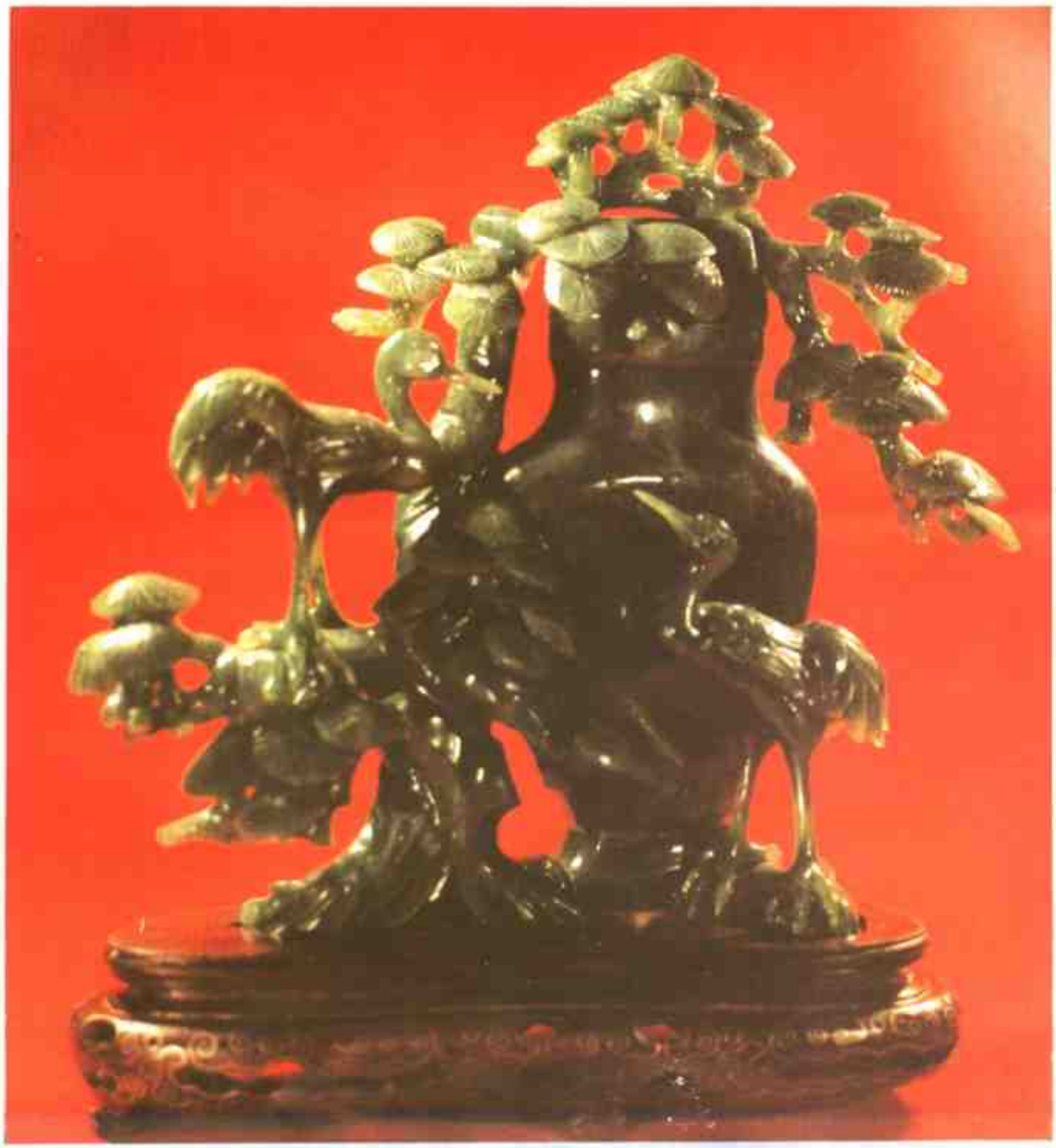
彩圖90　蜜蠟黃玉古錢(上)
The Ancient coin made of Wax-yellow Jade
彩圖91　蜜蠟黃玉獅子(下)
Wax-yellow Jade Lion





彩圖92　特斯翠玉(左)
Tekes Green Jade

彩圖93　特斯翠玉松鶴瓶(右)
Tekes Green Jade
carving miniature bottle
with cranes





彩圖94　綠松石
Turquoise

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