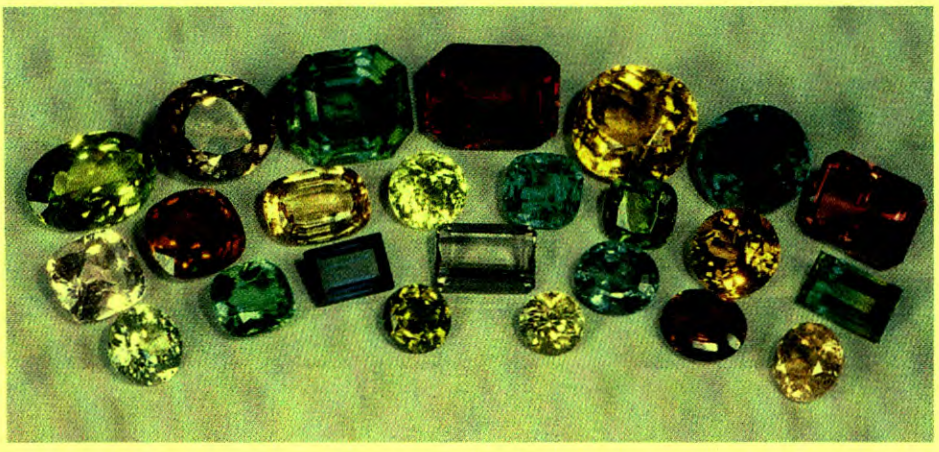
Special Report

Government of Pakistan
Ministry of Petroleum and Natural Resources

GEOLOGICAL SURVEY OF PAKISTAN

THEME PAPER
ON
ISSUES IN THE DEVELOPMENT OF

GEMS AND PRECIOUS STONES IN PAKISTAN



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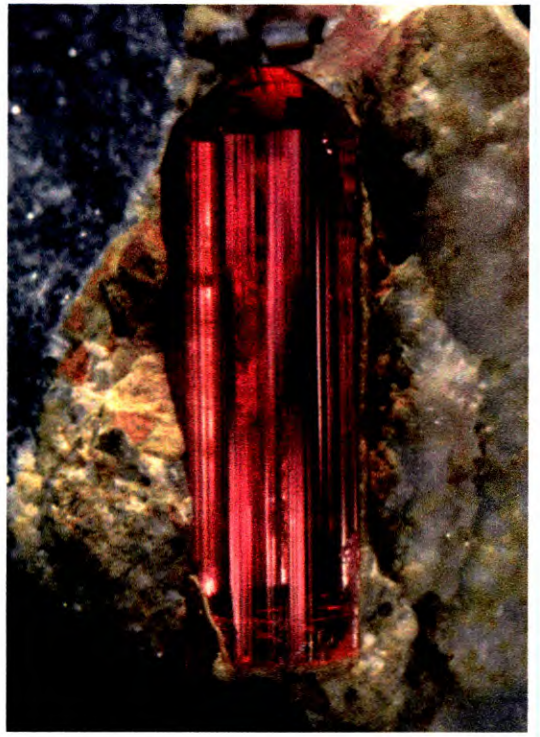
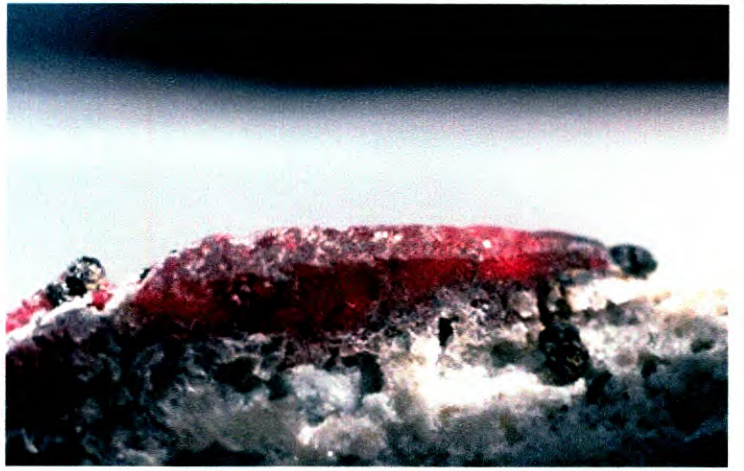
Government of Pakistan
Ministry of Petroleum and Natural Resources

SIGNIFICANT
GEMSTONES OF PAKISTAN





1. Pink Topaz, Katlang, Mardan (left)
2. Bi-colour Tourmaline, Northern Areas & AJK (right)
3. Ruby, Azad Kashmir (center upper)
4. Emerald, Swat, NWFP (center lower)

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GOVERNMENT OF PAKAISTAN
Ministry of Petroleum and Natural Resources

GEOLOGICAL SURVEY OF PAKISTAN
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Theme Paper
on

GEMSTONES IN PAKISTAN

INTRODUCTION

Gemstones are minerals which, when cut and polished, become precious and can be used in jewellery. They all share the common features of being extremely beautiful, rare, durable, and amenable to cutting and polishing. They have been used as objects of adornment, symbol of power and glory, and for exchange in trade since time immemorial.

At the time of independence in August, 1947 gemstones were not known to occur in the area now comprising Pakistan. However, beginning 1951 when GSP first discovered aquamarine in the Haramosh Range in Gilgit, a series of subsequent discoveries have made Pakistan a regular supplier of gems, precious and semi-precious stones to the international gem market but only a few are marketed as Pakistani gems.

Of the more than 3,000 identified natural minerals, fewer than 100 are now used as gemstones. This number has steadily increased during the past 20 years as before that only about 50-60 minerals were considered as of gem quality. Compared to the past, more minerals are now regarded as of gem grade. This could become possible due to advancements in exploration methods, identification techniques and optical enhancement processes leading to the finding of better crystalline forms of the already known mineral species or improving their colour by applying modern laboratory techniques

The great majority of gemstones is either of silicate composition such as emerald, aquamarine, peridot and amethyst or oxide like ruby, sapphire, spinel and

TABLE 1. **COMMONLY POPULAR GEMSTONES**

Transparent Gemstones

- Diamond
- Ruby
- Sapphire
- Emerald
- Chryosberyl
  - *Alexandrite*
  - *Cat's eye*
- Bcryl
  - *Aquamarine*
  - *Golden beryl*
  - *Morganite*
- Garnet
  - *Pyrope*
  - *Almandine*
  - *Spessartine*
  - *Grossular*
  - *Andradite*
- Kunzite
- Peridot
- Quartz
  - *Amethyst*
  - *Citrine*
  - *Smoky quartz*
  - *Rosy quartz*
- Spinel
- Tanazanite
- Topaz
- Tourmaline
- Zircon

Opaque Gemstones

- Agate
- Coral
- Jadeite
- Nephrite
- Lapis lazuli
- Malachite
- Moonstone
- Opal
- Pearl

Collector's Choice

- Actinolite
- Ambligonite
- Andalusite
- Apatite
- Axinite
- Benitoite
- Brazilianite
- Danburite
- Datolite
- Diopside
- Enstatite
- Epidote
- Euclase
- Euclase
- Fluorite
- Kyanite
- Moldavite
- Pargasite
- Phenakite
- Prehnite
- Rhodochrosite
- Rhodonite
- Scapolite
- Scheelite
- Sinhalite
- Mithsonite
- Sphene
- Taaffeite
- Thomsonite
- Willemite
- Zinc blende
- Zoisite

GENERAL PERSPECTIVE

The gem industry in the world has undergone a major qualitative change during the last two decades. These changes relate mainly to new techniques in cutting and polishing including using laser beams; artificial enhancement of colour and production of synthetic gems and simulants.

In more than 30 percent of cases, particularly in Europe, North America and Japan, the colour of gemstones is enhanced artificially. This is accomplished by any of the three methods: heating under controlled conditions; exposure to X-ray or radium; or the application of pigment as coloured foil to pavilion (base) facet.

In recent times various kinds of synthetic gems including rubies, sapphires, and emeralds, have been produced. Two methods of fabrication are currently employed; one involving crystal growth from solution and the other crystal growth from melts. While excellent quality coloured stones have been synthetically produced, a gem-quality diamond is yet to be produced. It is estimated that by 2020 more than 50 percent of the coloured gems trade in the world will be of synthetically produced gemstones or simultans. Synthetic gemstones essentially have the same appearance and the same optical, physical and chemical properties as the natural minerals that they represent. Simulants have an appearance similar to that of a natural gem material but have different optical, physical and chemical properties. Eventually in the future, simulants are likely to have such a favourale combination of desirable optical and physical properties that they will surpass the combined production of natural and synthetic stones.

GEOLOGY AND WORLD DISTRIBUTION OF GEMSTONES

Gemstones like other mineral deposits are a product of complex geological processes that have operated on and inside the earth for millions of years in an uneven style. Resultantly, the present occurrence and distribution of gemstone shows a remarkable diversity (Fig. 1). For example, Sri Lanka, a small island, is endowed with more gemstone in value than the whole of Europe or North Africa. Or, more than 90 percent of the diamond potential of the world exists only in Southern Africa and Siberia. Pakistan is fortunate in having a significant gem potential. Like the world-wide irregular pattern of distribution, the occurrence of gemstone in Pakistan is also confined to a few discernible geological zones in the northern mountainous belts of the country.

In the context of the gemstone occurrences the most fortunate are the very old shield areas of the world which are about 1.0 billion years old or still older. Of these, Brazil, East Africa, and South India and Sri Lanka are exceptional.

Gem minerals also occur in major fold belts across the world, with emeralds coming from the Andes in Colombia, the Urals in Russia and the Himalayas in Pakistan; rubies also from Himalayas in Pakistan and Nepal and their extension into Myanmar (Burma),

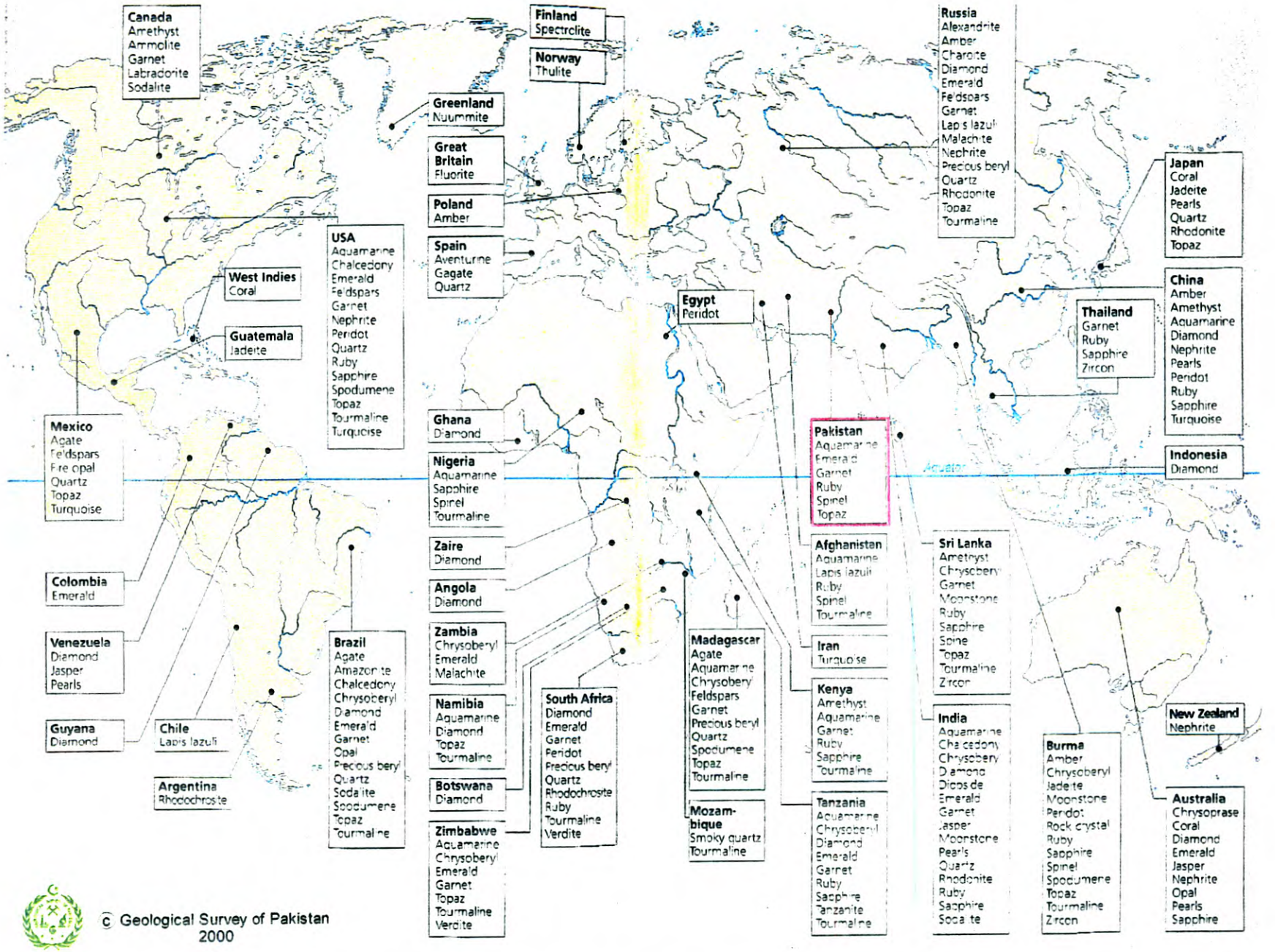

Fig. 1. MAJOR GEMSTONE OCCURRENCES OF THE WORLD

and jades coming from the Rockies in western Canada, the mountainous South Island of New Zealand and, again Myanmar. The Hindukush and sister ranges in Afghanistan and Central Asia are equally rich in these gems.

The pegmatites of Madagascar provide a whole range of gem minerals such as beryl, tourmaline, garnet, topaz, and spodumene (kunzite). Comparable specimens in a somewhat different tectonic setting come from pegmatite localities in California and Maine in USA; from Minas Gerais in Brazil, and from northern areas in Pakistan and northeastern part of Afghanistan. Gem-bearing pegmatites also occur in India.

Vast areas of New South Wales and Queensland in Australia, central Thailand and central Nigeria are covered with basaltic rocks which are associated with sapphires, rubies, zircons and spinels. Eastern and central Australia are also famous for their precious opal. The shield areas are again the locations for kimberlites and diamonds, the richest areas in gem-quality stones being southern Africa and Siberia followed by Australia and central Africa.

Because the gemstones occur in tiny crystals and small sizes, they have not been amenable to discovery or evaluation by direct exploration methods and also do not respond favourably to geophysical techniques. Even drilling is not of much use as it too can miss the crystal growth. The only exception to this generalization are some kinds of diamond-bearing volcanic pipes which can be explored by established methods. However, the recent advances in the studies on the genesis of different types of gemstones and their geochemical and geological characterization have highlighted the increasing role of accurate and meticulous geological mapping with proper structural and mineralized interpretations to find new zones, pockets and clusters of gemstone in areas of otherwise diminishing interest. This has been amply demonstrated recently by GSP in two areas of the country namely in Nangimali areas of Azad Jammu & Kashmir for ruby and in Kohistan District in NWFP for peridot. Therefore, the importance of geological mapping and associated laboratory research for future studies of gemstone in Pakistan cannot be underestimated. Recent studies of opal in Australia; emerald in Vietnam, Loas and Cambodia; and of gem-bearing pegmatites in Brazil bring forth the importance of high-definition geological mapping coupled with high-precision geochemical analyses including isotopic analysis. In short, the future of gem exploration throughout the world, as contrasted to the past, will have to be based on highly scientific considerations of geological and gemmological factors.

MINING

The mining of gemstones all over the world is a low-capital, low-technology operation and is predominantly done by the private sector. Public sector is almost non-existent except to a level of about 15 percent in Colombia, India, and Sri Lanka. The common methods of mining employed for extracting gemstones are:

- *alluvial (as for examples in Sri Lanka and in parts of South Africa).*
- *open pit (as for example in Colombia, Brazil and most other countries including Pakistan).*
- *Underground (as for example in South Africa & Australia and for aquamarine in Northern Areas, Pakistan).*

TABLE 2. MAJOR GEM PRODUCING COUNTRIES

S. No.	Country	Main Gemstone Types
	AFRICA	
1	Angola	aquamarine, diamond
2.	Botswana	diamond
3.	Burundi	diamond
4.	Central African Republic	diamond
5.	Congo	beryl, diamond, garnet, sapphire
6.	Egypt	peridot
7.	Ethiopia	garnet, peridot
8	Ghana	diamond
9	Kenya	alexandrite, amethyst aquamarine, garnet (tsavolite), rhodolite, ruby, sapphire, tourmaline
10.	Lesotho	diamond
11.	Madagascar (Malagasy Republic)	agate, aquamarine, beryl (pink), chrysoberyl, feldspars, garnet kunzite, quartz, scapolite, spodumene, topaz, tourmaline
12.	Mali	garnet
13.	Mozambique	beryl (morganite), emerald, garnet, smoky quartz, tourmaline
14	Namibia	aquamarine, blue tourmaline, diamond, garnet, spessarite, topaz
15.	Nigeria	aquamarine, green beryl (emerald ?), sapphire, spinel, tourmaline
16	Rowanda	diamond
17	Sierra Leone	diamond, ruby
18	Somalia	beryl, garnet
19	South Africa	diamond, emerald, garnet, peridot, precious beryl, quartz, rhodochrosite, ruby, tiger's eye, tourmaline, verdite
20	Tanzania	diamond, ruby, sapphire, tanzanite, tsavolite
21.	Zaire	diamond, malachite
22	Zambia	amethyst, aquamarine, chrysoberyl, garnet, emerald, malachite, opal
23.	Zimbabwe	aquamarine, chrysoberyl, garnet, golden beryl, emerald, euclase, rosy quartz, sapphire, topaz, tourmaline, verdite
	ASIA	
1.	Afghanistan	aquamarine, lapis lazuli, ruby, spinel, tourmaline
2.	Cambodia (Campuchia)	ruby
3.	China	amber, amethyst, aquamarine, diamond, fluorite, jade, nephrite, pearls, peridot, ruby, sapphire, topaz, turquoise

S. No.	Country	Main Gemstone Types
4.	India	agate, aquamarine, chalcedony, chrysoberyl, diamond, diopside, emerald, enstatie, garnet, jasper, moonstone, pearls, quartz, rhodonite, ruby, sapphire, sodalite
5.	Indonesia	diamond
6.	Iran	agate, pearl, turquoise
7.	Japan	coral, jadeite, pearls, quartz, rhodonite, topaz
8.	Laos	sapphire
9.	Mayanmar (Burma)	amber, chrysoberyl, jadeite, moonstone, peridot, quartz, rock crystal, ruby, sapphire, spinel, spodumene, topaz, tourmaline, zircon
10.	Oman	opal, quartz
11.	Pakistan	aquamarine, emerald, epidote, garnet, moonstone, pargasite, peridot, pink quartz, ruby, spinel, tourmaline, tsavolite
12.	Sri Lanka	amethyst, cat's eye, chyrsoberyl, garnet, moonstone, ruby, sapphire, spinel, taaffeite, topaz, tourmaline, zircon
13.	Thailand	garnet, ruby, sapphire, zircon
14.	Vietnam	ruby, sapphire
AUSTRALIA		
1.	Australia	chrysoprase, coral, diamond, emerald, jasper, nephrite, opal, pearls, sapphire, topaz, turquoise, zircon
2.	New Zealand	jade (nephrite)
EUROPE		
1.	Czech Republic	garnet, moldvite, opal
2.	Finland	blue beryl, spectrolite
3.	Germany	aquamarine
4.	Great Britain	fluorite
5.	Greenland	nuummite
6.	Italy	aquamarine
7.	Norway	thulite
8.	Poland	amber
9.	Russia	alexandrite, amber, charoite, demantoid, diamond, emerald, feldspars, garnet, lapis lazuli, malachite, nephrite, precious beryl, quartz, rhodonite, topaz, tourmaline
10.	Spain	agate, aventurine, quartz
11.	Turkey	beryl, chalcedony, diaspore, emerald, opal
12.	Ukraine	yellow beryl

S. No.	Country	Main Gemstone Types
NORTH AMERICA		
1.	Canada	amethyst, ammolite, garnet, jadeite (nephrite), labradorite, sodalite
2.	Guatemala	jadeite
3.	Mexico	agate, beryl, feldspars, fire opal, garnet, onyx, peridot, quartz, topaz, turquoise
4.	United States	agate, amethyst, aquamarine, beryl, chalcedony, emerald, epidot feldspars, garnet, green amazonite, kunzite, nephrite, opal, peridot, quartz, rhodocrosite, ruby, sapphire, spodumene, topaz, tourmaline, turquoise
5.	West Indies	coral
SOUTH AMERICA		
1.	Argentina	rhodochrosite
2.	Bolivia	topaz, tourmaline
3.	Brazil	agate, amazonite, andalusite, aquamarine, brozilianite, chalcedony, chrysoberyl, diamond, emerald, garnet, kunzite, opal, precious beryl, quartz, sodalite, spodumene, topaz, tourmaline
4.	Chile	garnet, lapis lazuli, turquoise
5.	Colombia	emerald, sapphire
6.	Guyana	diamond
7.	Venezuela	diamond, jasper, pearl

With the exception of Sri Lanka, parts of Brazil and the countries belonging to the North, the gem mining is mostly carried out in artisnal and small-scale working with much of it still done illicitly and in clandestine fashion. In most cases the state controls on the mining of gemstones in the majority of the countries are not strict. This may perhaps be due to the realization that exercising such controls over largely illiterate but organized labour, their patrons and semi-skilled groups and companies will be both expensive and only partially effective. Instead, promotional and facilitatory role to gradually educate the miners can be more effective and rewarding in the long run. Mining of gemstones by the public sector has failed invariably in almost all cases.

GEMMOLOGY

Changing the colour of gemstones by heat, by irradiation and by staining has become commonplace for the mineral species susceptible to such changes. While such treatment improves the beauty of some stones, to the jeweller it poses the problems of nomenclature for sale and marketing and of disclosure and book-keeping, if so required under legislation. In more than 30 percent of cases, particularly in Europe, North America and Japan, the colour of gemstones is now routinely enhanced artificially.

The turn of the century has brought further problems to those jewellers who are not scientifically trained. Extensive experiments carried out by scientists throughout the world began to produce results, and synthetic stones started to enter the field of commerce. At first only the ruby was so produced, then the sapphires of fancy colours. Later, the gems of spinel group were synthesized in a galaxy of lovely colours followed by synthetic emeralds. New stones which have little or no counterparts in nature are also now being synthetically produced. Diamond is also being synthetically produced for industrial applications but a fine gem quality synthetic diamond is yet to enter the market.

With the sophistication of demand and the increasing application of colour enhancement techniques, the role of gemmological research and studies has profoundly increased in recent years, so also the techniques for cutting and polishing including the newest laser cutting. But interestingly, this has not yet undermined the value of the traditional 'art' of gem cutting and valuation. For example, judging the colour of diamond is such a subtle work that experts in Antwerp, Belgium do it only 20 minutes a day. After that, even under powerful lights, they have trouble distinguishing the four categories of white that are 'whiter' than the white. The like is true for coloured stones such as emerald, ruby, sapphire and topaz. The skill and experience of gem artisans have no substitute and these arts can be developed only gradually over a certain period of time.

MARKETING

Apart from diamond which has a marketing context of its own, commerce in uncut coloured gemstones which is now estimated at more than 8.0 billion dollars per annum, is conducted on a person-to-person basis with no established set of prices either for rough material or for finished stones. Fluctuation in the supply of non-diamond gemstones makes it impossible to set up a regular pricing structure and dealers are thus obliged to keep a large number of commercial relationships with people in the supplying countries. Despite the

claims to the contrary, representation by companies at the actual mines is rare and most major gem mines pass their products to dealers in major commercial cities in the same country. From these dealers the rough stones are sent to cutters who may also act as stone dealers themselves.

Some dealers try to do business with particular countries and thus need to take into account the very definite preferences that different countries display. For example, star stones are not popular in every country but are greatly sought after in Japan, as also the cat's eye and chrysoberyl. Emerald has the best market in USA.

The price difference between an uncut and cut & polished coloured gemstone which used to be 1.30 in not too distant past has now increased up to 1:100 in some cases in recent years due to improvement in cutting and polishing techniques as well as because of artificial enhancement of colours. There is thus greater need and urgency to have suitable gemmological centres in the country, if Pakistan wishes to benefit meaningfully from its gemstone endowment.

Pakistan

Until a few years ago, Pakistan was unknown in the international gem market as a gem producing country. Most of the gemstones were smuggled out and sold as if they were coming from other countries. The situation has not much changed as yet and except for emeralds and the Himalayan or Kashmir rubies, Pakistan is still not a very familiar name in the international gemological circles. What is more surprising is that outside the circle of gem traders, a vast majority of Pakistani people, including jewellers, know so little about Pakistani gemstones. It is, therefore, not astonishing that in the international gem literature, Pakistan either does not find a place or is only cursorarily mentioned. The United States Geological Survey's last Yearbook (for 1996) although mentions Afghanistan for several gemstones, does not mention Pakistan at all. Similarly, the International Coloured Gemstone Association (ICA) gives only 3 lines to Pakistan in their last review while devoting almost a full page for India. During the past decade the internationally renowned gemmological research publications and journals have also remained devoid of any mention of Pakistan even for emeralds. In last two years GSP has made some efforts to enter into research collaboration with some prestigious European gemmologists and as a result one important monograph on 'Emeralds' published in French in 1999 contains a chapter on Swat emeralds. Additionally, some research papers on Pakistani emeralds and rubies will start appearing in reputed international journals by early 2001. Similarly, a few areas of high gem potential are now being systematically mapped by GSP in collaboration with renowned foreign scientists.

Apart from the better known emeralds and rubies, Pakistan is now reported to be sporadically producing about 30 different gems and precious stones. Besides, a large number of these are also smuggled into Pakistan from Afghanistan and possibly from some Central Asian Republics. Even some Indian, Sri Lankan and Thai gemstones also find a way into Pakistani markets. Peshawar has fast become an international market of gem and precious stones. The stones sold in Peshawar to foreign buyers or sent abroad from here for cutting and polishing are later marketed as Indian stones at prices several times higher than the original selling price. It is roughly estimated that the illicit mining and illegal export of Pakistani gemstones and jewellery may be several time more than the legitimate export estimated at around Rs. 450.0 million during 1998-99 compared to Indian exports of gems and jewellery at Rs. 7.0 billion for the same year and a target of Rs. 10.0 billion for the year 2000.

Pakistan established a Gemstone Corporation in 1978 which was liquidated in less than two decades due to mounting losses. Presently the major emerald and ruby mines are officially closed due to various litigations but nevertheless the gems are being illicitly mined and coupled with the gems coming from Afghanistan and elsewhere, there is apparently no shortage of any gems in the domestic market.

An acute lack of knowledge and skills about the modern trends and fashions in stone jewellery and in the art of cutting and polishing gemstones is mainly responsible for the insignificant contribution to the exports from Pakistan. Avoiding the harder and the painstaking part of learning and practicing the art of gem cutting and polishing, the gem traders generally prefer to export or smuggle out rough and uncut gemstones.

The Afghanistan Factor

Afghanistan has been traditionally a gemstone producing country. The legendary 'Laal-e-Badakshan' (ruby) has come from Afghanistan. However, about 90 percent of the Afghan gem production now comes from the famous 'Panjsher valley' to the north-northeast of Kabul presently held by the forces of the Northern Alliance. In last two to three years the quantity of gemstones coming into Pakistan has shown some perceptible decline which at least in few cases may either be indicative of a depleting resource base or a result of difficulties of mining and recovery at deeper depths. There are also reports that some high quality rubies and sapphires from Panjsher valley have now been directly sent to foreign buyers by the traders in northern Afghanistan avoiding the Pakistan route. The Afghan factor is important in evolving long-term strategy for the growth and export of gems and jewellery from Pakistan. Many gemstones which are marketed as Pakistani gemstones in Peshawar and other cities of Pakistan are most certainly not of Pakistani origin and have come from that country or the Central Asian Republics.

The Indian Factor

The Indian gems and jewellery can also be easily found in Pakistan with Lahore as its largest centre. Being cheaper than the jewellery in the Middle East and Europe, the Indian gem-studded jewellery is quite popular locally. Cultural similarity in the style and fashion of jewellery-making is also an important factor in the popular acceptance of Indian jewellery. Contrary to the perception held in Pakistan, India is regularly producing more than 20 types of gems and precious stones including emerald and sapphire although Pakistani emerald is still far better in colour than the Indian stones. Recently, some interesting gem discoveries have been reported from Orissa, Tamil Nadu and Rajhastan.

Mumbai (Bombay) is an important diamond cutting centre of the world while Jaipur in Rajhastan has 3 important centres for cutting and polishing coloured stones. The Jaipur centres alone employ more than 20,000 artisans and well-trained master cutters.

It will be interesting to note that almost half of the Indian gem-studded jewellery exported by lit is consumed by the Indian migrants settled in Middle East, Europe and North America. By and large the Indian jewellery has not dented the traditionally high style, high fashion Italian, French and American jewellery. India at present has no worthwhile facilities for colour enhancement of gems or to produce synthetic gems and simulants.

GEMSTONE OCCURRENCES OF PAKISTAN

A large variety of gemstones are found in Pakistan (Table. 3). Some of these are being mined while others are being produced as mineral specimens. From the geological point of view, the gemstones of Pakistan are (i) suture – associated such as emerald, peridot, actinolite, ruby, sapphire, spinel and pargasite, (ii) pegmatite – associated like aquamarine, emerald, feldspar, garnet, quartz, topaz and tourmaline, (iii) gemstones in hydrothermal veins which include azurite, pink topaz, rutile and zircon, and (iv) miscellaneous occurrences of agate, green grossular garnet and hessonite garnet. The Northern Areas of Pakistan can be rightly regarded as a kingdom of gemstones. In this high-alltitude terrain all of the four categories of gemstone associations are reported (Table. 4). A brief description of Pakistani gemstones is given in the following summary.

Actinolite

Actinolite is one of the ampmhibole group of minerals. It includes the jade mineral nephrite. It has an attractive green colour and is easy to cleave but difficult to cut and polish. Gem grade transparent crystals of actinolite of exquisite deep green colour are found in metsmorphosed greenstones and in talc-chlorite-actinolite schist in the suture zone near Bunji and Chilas in Diamir District and in the Charbagh-Alpurai area of Swat District.

Aquamarine

Aquamarine is a silicate of beryllium and aluminium and belongs to the beryl group of minerals. It is an attractive gemstone liked for its exquisite light to medium, sparkling blue colour and for its clarity and brilliance. Aquamarine occurs in the pegmatites of the Karakorams and the northwestern Himalayas. Light blue, clear euhedral crystals of aquamarine are common in the gem-bearing pegmatites of Gilgit and Skardu areas. The better known deposits are at Iskere, Shingus, Dusso and Tisgtung.

Deeper colour varieties occur in Chitral District at Gobor-o-Bakh locality. Apparently this region has a good potential for the better priced, deeper colour aquamarine and merits further exploration and development.

Emerald

Emerald is also a member of the beryl group of minerals and is cherished and fancied for its exquisite verdant green colour. The best and most precious colour is the intense and clear dewy green of fresh spring grass. It owes this magical colour to traces of chromium in the beryl's crystals.

In Pakistan, Mingora, Gujar Killi and Shamozai areas situated in Swat District are now well known for producing top quality emerald. The emerald is found in ophiolitic mélange zone along the Main Mantle Thrust. Emerald also occurs at Dandao Kandao, Nawe Dand, Gandao, Kot, and Mor Dara in Mohmand Agency; Arang Barang in Bajaur Agency; Makhad and Charbagh in Swat District; and near Khaltaro in Gilgit area.

Mingora emerald deposits: These are the best known deposits located at the northern edge of Mingora city, 200 km to the northeast of Peshawar and were first studied by GSP in late 1960s. Emeralds occur in Mingor a ophiolitic melange, which appears in the form of highly tectonised

Table 3.

1. Actinolite
2. Agate
3. Aquamari
4. Amazonite
5. Azurite
*6. Beryl
*7. Emerald
* 8. Epidote
* 9. Garnet (a
10. Garnet (g

* reportedly bei

fault blocks. Two parallel north-trending normal faults run through the deposits and are believed to be the principal avenues for mineralizing fluids. The Swat deposits have produced excellent quality material which has been described as being **'some of the finest emeralds in the world'**. These have become well known for their brilliant, medium to deep green colour as well as for their unique transparency which is comparable to the finest Colombian specimens from Muzo.

The average size distribution of emeralds has been approximately of the following order:-

	Size (carats)	Percentage (%)
a.	Mellee	45
b.	0.5-1	33
c.	1-2	7
d.	above 2	15

Average gradewise distribution of the rough gem-grade emeralds produced from the Mingora mines is approximately as follows.

Grade	Percentage (%)
Excellent	5
Very good	12
Good	25
Fair	13
Mellee	45

Gujar Killi emerald deposit: This deposit is located near Gujar Killi village 24 km to the east-northeast of Mingora and 12 km to the south-southwest of Alpurai in Swat District. The emerald deposit occurs in a small trianglular outcrop of ophiolitic mélange which is surrounded by Saidu graphitic schist. The deposit covers an area of about 10 acres.

A number of small northwest-trending faults with cross-cutting fractures and joints cut through the mineralized block and the emeralds largely occur along these faults and fractures. Open cast mining has been done and in recent years emerald production has increased from about 6,000 carats (cts) in 1986-87 to about 80,000 cts by 1996-97. Emeralds occur in the form of large well formed, dark green euthedral crystals up to 100 to 200 cts in weight. This is a promising deposit which merits proper scientific exploration, mining and mine development. There are good prospects for obtaining much higher production from this deposit.

Shamozai emerald deposit: Located about 24 km to the west of Mingora, the deposit occurs at an altitude of about 2,000 metres along the general strike. Mineralization occurs in talc-carbonate schists of Indus Suture Melange group under geological conditions very similar to Mingora and Gujar Killi. Emeralds are transparent and of good green colour. Bicolour emeralds have also been reported from this area.

Other emerald deposits: Emeralds occur also at Dandao Kandao, Nawe Dand, Gandao, Kot, and Mor Darra in Mohmand Agency; Arang Barang in Bajaur Agency; Makhad and Charbagh in Swat District and near Khaltaro in the Gilgit area. These deposit have not yet been systematically explored.

There is great potential for enhancing emerald production in Pakistan. However, the exploitation of this potential requires systematic exploration and detailed studies mostly in a 150-km long **'Emerald Belt'** which lies between the Indus suture zone and the metasediments and ophiolitic mélanges of the Bajaur and Mohmand Agencies.

Epidote

Epidote has a characteristic yellow-green colour to a deep olive green colour. In Pakistan, most of the gem grade deposits of epidote occur in hydrothermal veins and as alteration product in gabbro and greenstones of the mélange complex. These deposits are located in the Indus suture zone close to Bunji in Gilgit area near Kot, Pranghar, and Bucha in Malakand and Mohmand Agencies and at several localities in Swat District.

Garnet

Garnets comprise a large mineral group whose members have different names corresponding to their appearance. The more common gemstones of the garnet group are *pyrope*, which has a glowing red colour; *almandine* has a brownish red to reddish violet colour; *rhodolite* commonly has a rose-red colour and strong lustre; *spessartine* has an exquisite orange hue and is one of the most exquisite garnet; *grossularite* varies in colour from brown, reddish brown, clear sparkling copper-gold to green; and lastly green *demantoid* which is the most unusual and rare amongst the garnets and fancied for its brilliance and fire.

Gem quality almandine is found in Chitral District; and red spessartine is associated with pegmatites of Dusso and Shingus in Northern Areas. *Tsavolite* or green grossularite is associated with graphitic schist in Jambil area of Swat, near Kot in Malakand Agency and near Targhao in Bajaur Agency. Beautiful honey-yellow euhedral crystals of *hessonite* are found in quartz-mica schist near Targhao in Bajaur Agency.

A high quality, orange, orange-red spessartine garnet has been recently discovered in pegmatites in Neelam valley of Azad Kashmir. This deposit has yielded large transparent crystals.

Moonstone

Moonstones belong to the ranks of the rock-forming feldspar family. The feldspars are one of the most widely distributed minerals. The moonstones vary in colour from misty soft grey to spring clear, shimmering silvery white, reddish-brown to light blue.

In Pakistan, moonstone has been reported from the pegmatites of Shingus and Bulechi in Gilgit area. The deposits appear to be fairly large in size and are of good quality.

Pargasite

Pargasite is a monoclinic amphibole. Exquisite deep pistachio green crystals of pargasite are found in the metamorphosed crystalline marbles alongwith ruby and spinel in Hunza valley. These are translucent to opaque and are commonly fashioned into beautiful cabochons. Locally they are sold as 'Hunza emeralds'.

Peridot

Peridot is the aristocaratic representative of the olivine family and is a complex silicate of magnesium and iron. It is admired for its golden olive green colour and littering lustre.

In Pakistan, an important deposit of peridot and the first in the country was discovered by GSP a few years back near the Kohistan - Kaghan watershed to the northeast of Naran. The gemstones occur along shear zones and in pockets in dunitic host rocks and are associated with clinochlore, magnetite and minor magnesite. The host rocks occur in the immediate hanging wall of the Indus suture.

The peridot is transparent to translucent and pale to dark yellowish green or, rarely, greenish yellow. A good proportion of the specimens is of brilliant gem quality and adequate size, and is thus suitable for faceting. It is medium to coarse-grained with largest crystals reportedly measuring more than 10 cm in length and up to 2 kg in weight.

Quartz

Quartz is silicon dioxide (SiO_2). It is a common rock-forming mineral but also includes a wide variety of ornamental types. The ornamental varieties can be crystalline such as amethyst and citrine, or cryptocrystalline such as agate, chalcedony and cornelian.

Clear and well formed crystals of quartz occur in gem pegmatites in Skardu, Gilgit and Chitral areas, and in Azad Kashmir. Smoky quartz is also commonly found in these areas. Rosy quartz is abundant in Dusso pegmatites near Skardu.

Agate and chalcedony are found near Nagar Parkar in Tharparkar District, Sindh, while jasper occurs in Las Bela area (Balochistan). But presently these occurrences are not yielding commercial stone.

Rodingite

Rodingite is a low grade metamorphic rock largely comprised of hydrous calcium-aluminium silicates. It has an attractive high to medium green colour. Some stones are of a light cream colour mottled with specks of green. It is mainly used for gem carving and for making beds and cabochons. It is also used for making artifacts. The ultramafic complex in the Malakand Agency near Dargai contains large and extensive layers and lenses of rodingite.

Ruby

Ruby belongs to the corundum family and owes its popularity to the gorgeous glowing red colour which is the embodiment of the most beautiful red.

In Pakistan, the main ruby deposits occur in a dolomitic marble belt extending for over 100 kms from Hunza valley to Ishkuman, close to the Main Karakoram Thrust. Mining is, however, presently confined to 13 mining centres spread over a length of 15 km in Hunza valley. Ruby deposits of Azad Jammu and Kashmir (AJK) are located in Nangimali, Khora-Katha, Chitta Ratta and Naril Nala areas. They are associated with meta-limestones and occur in calcite

veins along bedding planes. The rubies are transparent to translucent and brownish pink to pinkish red or deep red. The deposits are being mined sporadically and the reserves appear to be fairly large. Ruby also occurs as corundum in a 30 - km long belt of amphibolites around Timurgarha in Dir District, NWFP. It is, however, of a lower grade.

After Mayanmar (Burma) and the recently discovered rubies in Vietnam and Cambodia, the Hunza and the Neelem valleys in Pakistan are the only other regions of the world that are capable of producing "blood red" rubies. Cabcochon grade violet or indigo-coloured sapphires also occur with rubies. The blood red rubies in the present day gem market fetch a very high price. Thus there is great potential for development of ruby deposits of Pakistan.

Sapphire

Blue coloured sapphire crystals are occasionally found in some of the metamorphosed carbonate rocks in NWFP., Azad Kashmir and Northern Areas which are commonly yielding rubies and spinels.

Spinel

Spinel is a magnesium aluminate and occurs in sharply defined octahedral crystals. Spinel is admired for its lovely vibrant colours, strong brilliance and striking clarity. It can withstand great heat without change and occurs in all shades of red to rose-red. The orange-coloured fire spinel is an extremely beautiful variety. Purple to blue and blue-green varieties are also common.

Spinel with its ruby red colour is closely associated with Hunza ruby deposits. The Hunza spinels occur in a wide variety of colours ranging from brown, red, plum red, violet to blue. These colour variations are mainly due to slight changes in their chemical composition. For example, the red colour is largely due to the presence of chromium, whereas the bluish and plum-coloured varieties owe their colour to the presence of iron.

The Hunza spinels are larger than those customarily found in Mayanmar (Burma) and are far more attractive. They are often euhedral showing recognizable crystal forms.

Serpentine

Serpentine has a relatively low hardness but stones of attractive green colour provide excellent material for carving. Some of it is being cut into cabochons for inexpensive jewellery and used as decorative stone. Extensive deposits of serpentine are associated with the mélange/ophiolitic belt in the Gilgit area and in the Swat, Malakand, Mohmand, Kurram and Waziristan, in NWFP and Zhob and Lasbela areas in Balochistan.

Topaz

Topaz is a fluoro-silicate of aluminium and is priced for its glowing, firely sparkle and its wide range of exquisite colours ranging from yellow to golden brown, rose-red to peach-pink, blue to shining azure-blue and colourless to pure white. The yellow variety resembles citrine (yellow quartz), but it is incomparably more beautiful and attractive mainly due to its higher refractive index, hardness and specific gravity.

Topaz found in gem pegmatites ranges from colourless to slightly yellowish brown to a deeper cherry colour and large perfectly euhedral crystals are quite common. They mostly appear in a microcline-quartz-muscovite matrix. Topaz bearing pegmatite are largely found at Bulechi. Shingus and Gone near Dusso in the Skardu area in Baltistan.

Pink topaz

Pink topaz ranging in colour from deep red, orange-rose or cyclamin colour is unique to Katlang topaz deposit. In fact, this is the only known naturally deep red or deep pink coloured topaz in the world. The colour of these Katlang stones ranges from colourless to very pale beige to light brown and from pale to deep pink bright red. Even violet coloured crystals have been found.

The Katlang deposit is located in the Ghundao hillocks 4 km to the north of the town of Katalang, about 20 km to the north of the city of Mardan and 60 km to the northeast of Peshawar. The Katlang hillock comprises a small anticilinorium with fold axes trending east-west. It is composed of grey, thin to thick bedded Palaeozoic crystalline limestones which have been dragfolded and extensively faulted. The limestones contain extensive stockworks of calcite while quartz veins mostly occur along a series of parallel, normal and reverse faults near the crest of tightly folded anticlines.

Pink topaz of Katlang is a unique stone unparalleled in the world. It is found only in Pakistan and if properly promoted in the world market then its price can be greatly enhanced.

Tourmaline

Tourmaline is a complex borosilicate of aluminium and as a gemstone it is famous for its beautiful colours, occurring in all possible hues and shades. It is found even in mixed colours as a bicolour or tricolour gemstone. The more common hues are ruby-red (*rubellite*) and orange through brown to yellow, green and blue (*indicolite*). Tourmaline comprises several distinct mineral species, and many of these provide specimens of gem quality.

Deposits of gem quality tourmaline are found in the pegmatites of the Haramosh Range, near Gilgit (pink, blue, and green varieties). The best known deposits are located in Stak Nala (between Gilgit and Skardu). This locality is now famous for bicolour and tricolour tourmaline. Gem grade tourmaline also occurs at Bulechi and Shingus in Gilgit. Indicolite (blue tourmaline) is found in the pegmatites of Garm Chashma (Chitral). Green tourmaline has been found in pegmatites of Donga Nar in Azad Kashmir. Some of the best and fairly large specimens of bi- and tri-colour tourmaline have been found in these pegmatites.

Vesuvianite

Vesuvianie is a complex calcium-aluminium silicate having chemical and structural similarities with grossular garnet. Exquisite pistachio green tetragonal crystals of vesuvianite called idocrase were found in the calcite veins in the ultramafic complex near Muslimbagh in Zhob District, Balochistan. Though the original deposit was soon exhausted, crystals of

vesuvianite have reappeared in the Quetta market recently suggesting that the local tribesmen may have now discovered a new source. A massive green rock composed of cryptocrystalline grains of vesuvianite forms large lenticular bodies in serpentinites to the west of Dargai in Malakand District, and to the northwest of Pranghar in Mohmand Agency. It is being used as a decorative stone for carving and for making cabochons.

Mineral Specimens

The attraction of a mineral specimen as distinct from a facetted stone lies in its form and colour. Mineral specimens do not have to be of gem quality, though the gem crystals that escape cutting are often admittedly the most beautiful in colour but may have cracks and fractures. In recent years a large and flourishing market for good mineral specimens as collector's items has developed world wide.

The pegmatites of the Northern Areas have yielded excellent mineral specimens including light pink crystals of fluorapatite, green fluorite, spessartine, hambergite, green microcline, aquamarine, tourmaline, topaz and garnet. Exquisite mineral specimens of ruby, spinel and pargasite are found in the Hunza valley (Table-1).

Beautiful pyrite, malachite and azurite specimens can be collected from near Gilgit. Attractive violet colour fluorite crystals occur in the Koh-i-Maran and Dilband areas in Mastung and Kalat Districts, Balochistan. Agate and turquoise are reported from near Nok Kundi in Chagai District, Balochistan while opal-like material has been reported from Nagar Parker area in Tharparkar District, Sindh. Beside these, the occurrences of zircon, rutile, vesuvianite, rodingite, jadeite, actinolite and epidote reported in northern mountainous regions need further prospecting and can yield substantial amounts of high – price collectors' specimens.

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Table 4. Gem Pegmatites of Northern Areas and Their Mineral Content

Location	Altitude (metres)	Gemstones	Other minerals.
KARAKORAM			
Dusso	2,800-3,000	Aquamarine Rose quartz	Plagioclase feldspar, quartz, muscovite, biotite, schorl, beryl.
Nyet Bruk	4,600-5,000	Brown topaz	Plagioclase feldspar quartz, tourmaline, muscovite, beryl.
Gone	2,600-3,000	Aquamarine Brown topaz Schorl	Plagioclase, orthoclase, quartz, muscoite, beryl, biotite
Tigatun	2,600-3,000	Aquamarine Garnet	Plagioclase, quartz, muscovite, biotite, achorl, beryl.
HARAMOSH			
Stak Nala	3,300-4000	ticolour tounnaline Aquamarine	Feldspar, quartz, mica, fluorite, apatite, schorl, beryl
Skhere Shah Batot Shingus	2,300-4,000	Aquamarine Topaz Goshenite Morgamte	Feldspar, quartz, mica, garnet, schorl, tourmaline, beryl.
Khaltaro	4,600-5,000	Emerald Aquamarine	Feldspar, quartz, mica, scion, betyl.
DEOSAI MOUNTAINS			
Bulechi	2,600-4.000	Topaz Aquamarine Green tourmaline Bicolour tourmaline Moonstone	Feldspar, quartz,. Mica, ,schorl, garnet. Beil.
NANGA PARBAT			
Astore	2,500-4.000	Smoky quartz Green quartz (large books of mica)	Quartz. feldspar schorl. garnet, beryl, mica.
Buldargah	2.600-3,300	Aquamaiine	Quartz. feldspar, mica. schorl, garnet.
HINDU KUSH			
Gobato - Bakh (Luthko).	5,000-6,000	Aquamarine Tounnaline, garnet Quartz	Quartz. feldspar, mica. tournialme, beryl.
Dan (Than	4.000-5.6000	Aquamarine, Garnet	Quartz,. Feldspar, mica.

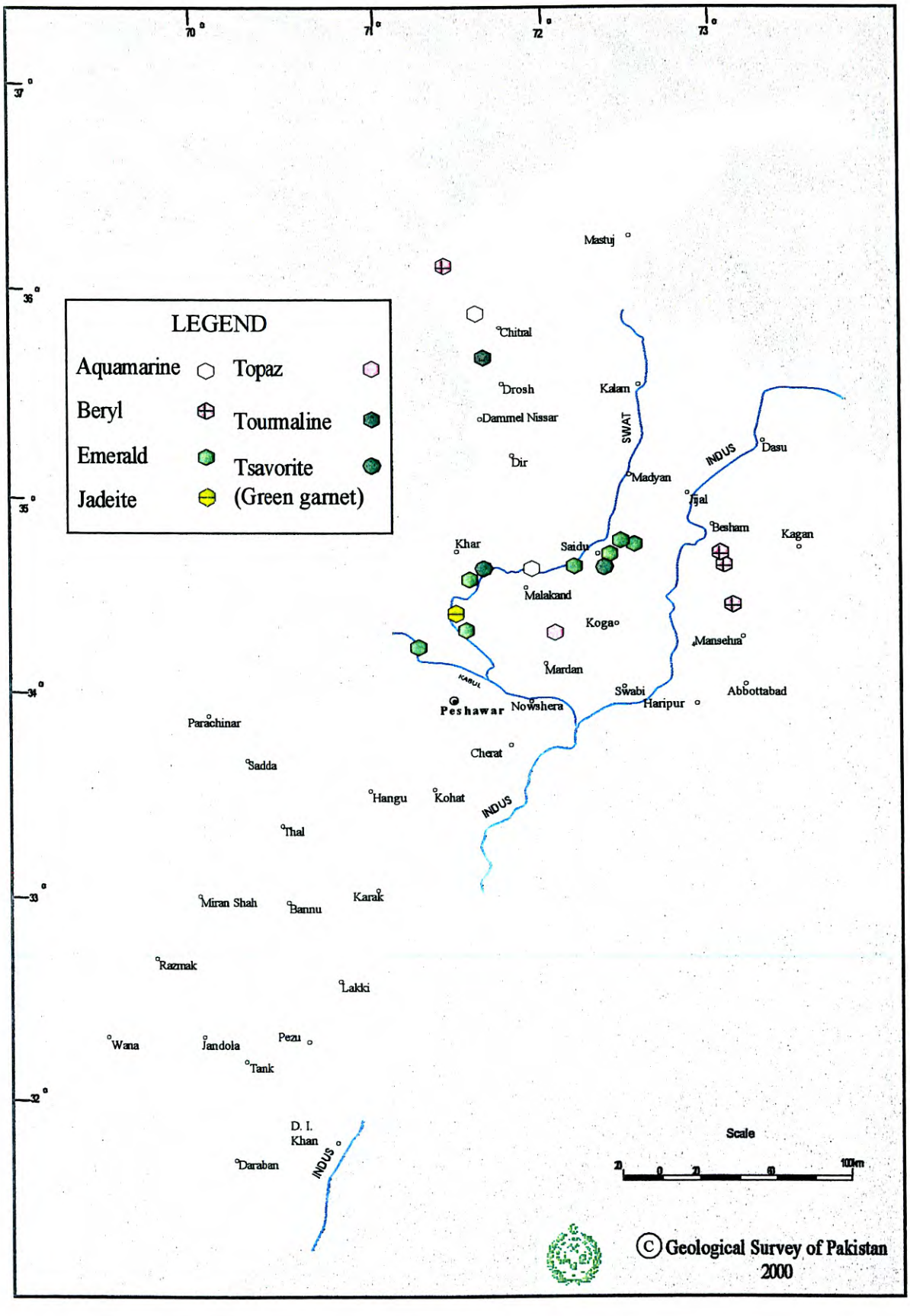

Fig. 1 MAJOR GEMSTONE OCCURRENCES IN N.W.F.P., PAKISTAN

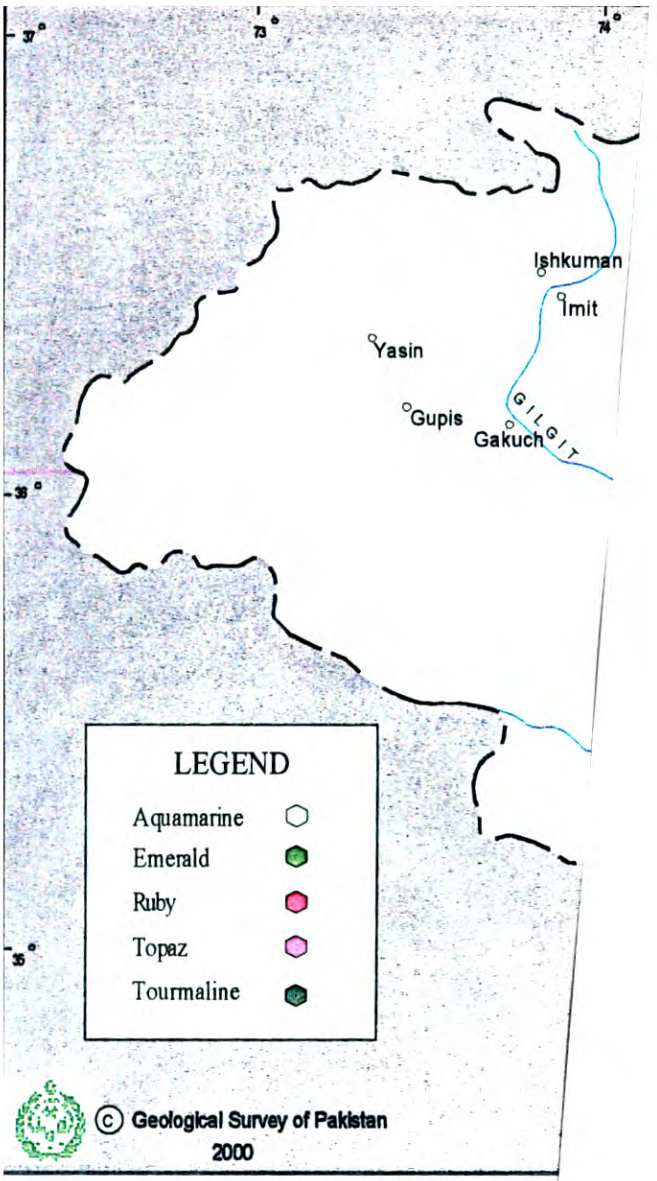

Fig. 2 MAJOR GEMS

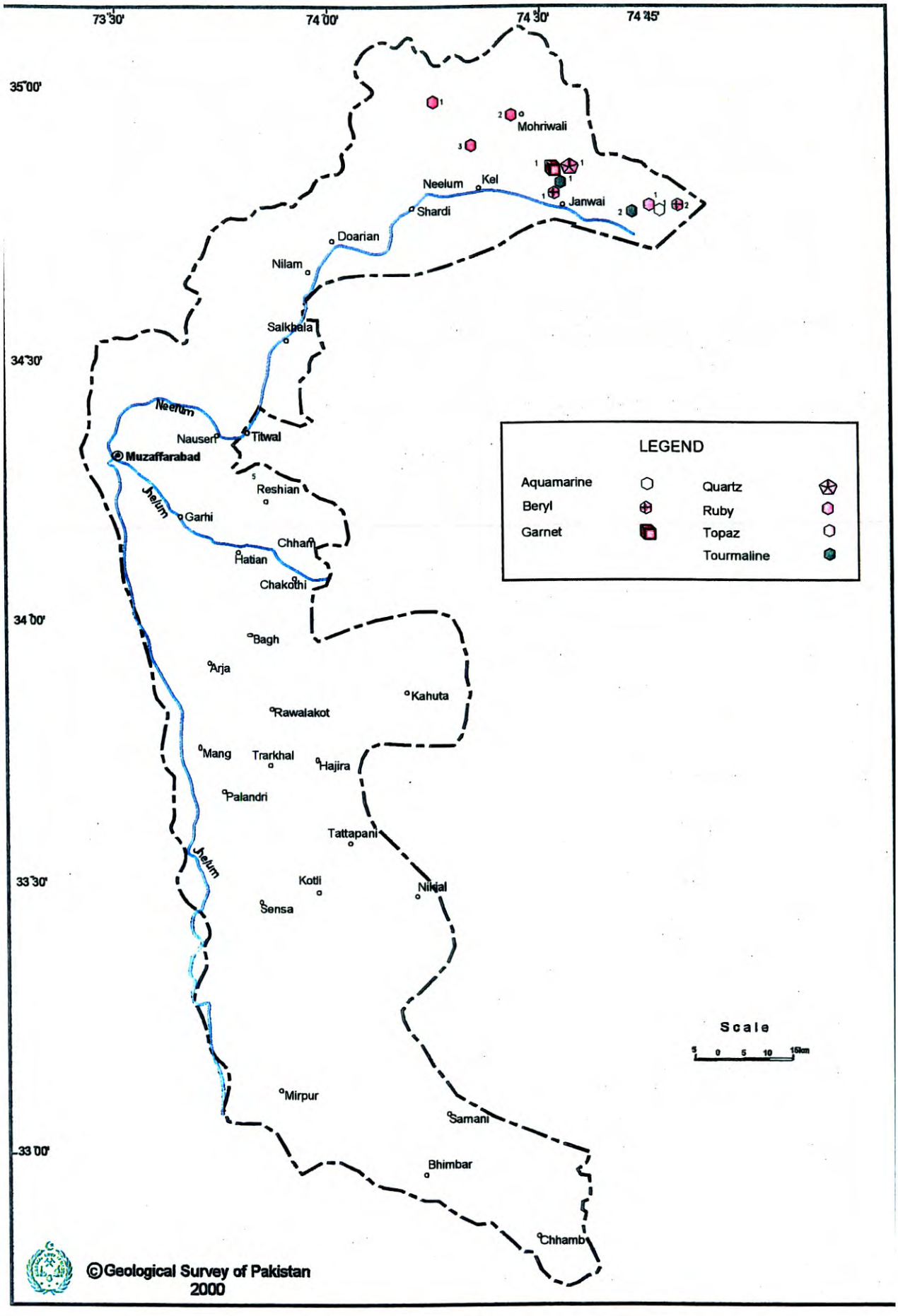

Fig.3 MAJOR GEMSTONE OCCURRENCES IN AZAD JAMMU AND KASHMIR

PROPOSED STRATEGY FOR THE DEVELOPMENT OF GEM & JEWELLERY INDUSTRY IN PAKISTAN

(1) The present constitutional provisions for granting and administering the prospecting and mining leases of gemstones should remain unchanged. Only more transparency and openness should be introduced through acceptable executive & administrative measures.

(2) Free import of gem mining, cutting and polishing equipment, machinery and spares should be allowed for 3 years. This should also include imports from India. This is essential to facilitate export/re-export of Pakistani finished products.

(3) Export of gems and jewellery should be free of all duties, taxes and controls for the next 3 years.

(4) Special handling facilities should be provided at the international airports in Pakistan for the export of gems & jewellery. The Export Promotion Bureau be made the lone contact/focal point to process, approve and oversee all export deals.

(5) There is presently no scientifically trained gem expert in the country. Foreign assistance should, therefore, be sought from UNDP/UNIDO or the Europeon Commission to conduct an all-embracing scientific study of gem mining, processing, marketing and export.

(6) The already approved project of establishing a Gem Training Institute at Peshawar by the Export Promotion Bureau should be expeditiously implemented.

(7) To provide the critically essential scientific support to the gem industry, the GSP's proposal to establish a Gemmological Research Centre (GRC) within its Geoscience Lab (GeoLab) at Islamabad costing Rs. 38.0 million should be immediately approved and its implementation started within the current financial year. If this is so done, then GRC can start certification work by the year 2003. Developing indigenous certification capability is a very important factor in the future growth of gem industry in Pakistan and creating a dependable export market.

(8) Besides the two proposed centres at (6) & (7) above, the private sector should also be encouraged and facilitated to set up its own gem cutting, polishing and lapidary centres and jewellery designining/making centres.

(9) A high level Gem & Jewellery Industry Facilitation Board should be set up in the Federal government to facilitate and coordinate all activities of the gem & jewellery industry with members drawn from all concerned quarters.

(10) With the growing personal wealth, China and Japan are likely to be major gem markets of the future. Pakistan should now more specifically concentrate on these two countries.

(11) People in Middle East, Japan, Europe and North America generally have taste for designed/custom jewellery different from that produced by India. Pakistan should try to take maximum advantage of this difference and use this to introduce its own branded jewellery.

(12) Diamond is at the center of all gems & jewellery. The diamond cutting should be an essential feature of Pakistan's future gem strategy. No Muslim country has a worthwhile diamond cutting center although they consume about $1/5^{th}$ of the gem diamond.

(13) An aggressive publicity of Pakistan's gem potential should be projected nationally and internationally. TV documentaries, special newspapers supplements, and popular books and feature articles should be produced. Gem windows should be opened in Pakistani Missions abroad and permanent gem exhibitions should be set up at Karachi, Lahore, Islamabad, Peshawar, Quetta, Faisalabad, Gilgit and Skardu.

(14) Like the Pakistani fruits, carpets and handicrafts, the Pakistani gems, both cut and uncut, should also be made objects of state gifts and presents.

(15) The government should try to promote and encourage the formation of private limited companies in mineral gem & jewellery industry having sound professional and financial capital. It should also encourage and facilitate in developing branded jewellery in the country both for domestic consumption as well as export.

(16) Booklets in English and Urdu should be published containing the entire set of rules, regulations, SROs etc. governing gems & jewellery business; from prospecting & mining to value addition and export.

(17) Gem merchants and jewellers should be included in the official trade delegations sent to foreign countries.

(18) A small team of officials should be selected and sent abroad for a study tour to selected gem producing/processing countries and the principal gems centres of the world. This team will later create similar facilities/operations in Pakistan conditioned according to the local situations.

(19) More active participation (including at official level) should be ensured in the various international gems & mineral shows.

(20) Gemmology may be introduced as a special paper for Master's degree in Geology in selected universities. Initial assistance in this regard can be provided by GSP. Similarly, courses in jewellery design can be developed and offered in some institution(s) like the National College of Arts, Lahore.

(21) Pakistan should become member of the International Gemmological Association and the International Coloured Gemstone Association.

(22) Based on the results of the concessionary and promotional measures enumerated above, a 'Gem & Jewellery Act' should be promulgated and a Gem Regulatory Authority established by mid 2003 to promote, facilitate, and regulate all facets of gem trade and industry and then suitable amendments may also be made in the National Mineral Policy.

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