

NISCAIR DIAMOND JUBILEE CELEBRATION SEPTEMBER 2011-2012



PRECIOUS MINERALS IN EVERYDAY LIFE



The Wealth of India Division

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India is covered in natural resources derived from plants, animals and minerals. In everyday life all of them are used by us in many specialized ways. Minerals contribute to economy of the country and they are with us since morning starting from alarm clock, utensils and other utility items in kitchen, electric light switch, petroleum products, glass and ceramic pots, building materials, appliances, toothpaste, jewellery, lubricants, paint, fertilizer, photography, drawing materials, coatings, machinery and many more. Most of us have never realized our reliance on these hidden resources.

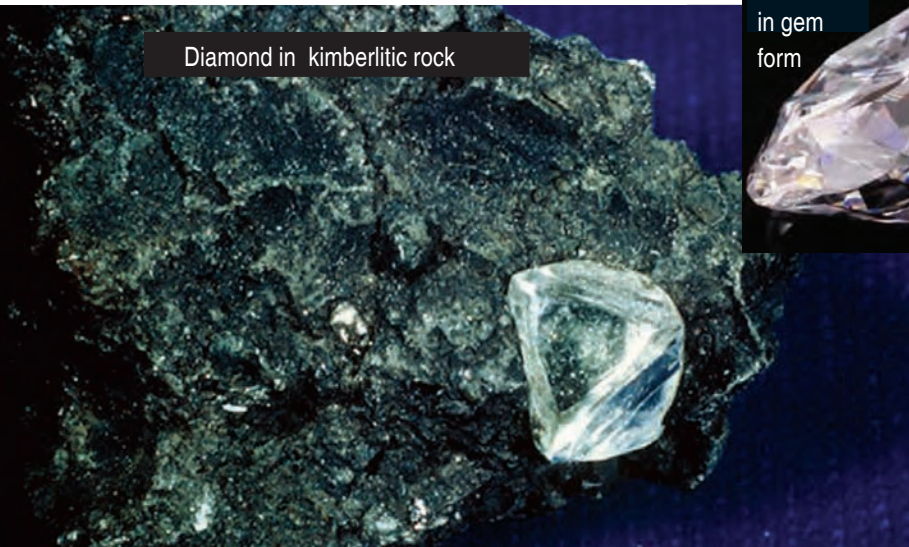
This extension bulletin, dedicated to the Diamond Jubilee year of the Institute, is designed to provide information on 10 major and precious minerals involved in our every day life and add prestige, position and prosperity. Instead of including detailed information in this small bulletin we have included, What they are? Where they are found? and How they are used in daily life? We hope that readers will find this illustrated bulletin interesting and informative.

Diamond

Diamond, the most precious and fascinating mineral, is known as *Vajra* and *Hirak* in Sanskrit and Hira in Hindi. Diamond is a transparent crystal of tetrahedrally bonded carbon atoms. Diamonds have been known and treasured as gemstones since ancient times. As its name in Sanskrit denotes it is very strong and unbreakable mineral. It has the highest hardness and thermal conductivity as compared to any natural substance. Somewhat related to hardness is another mechanical property which diamond possesses is toughness, which is a material's ability to resist breakage from forceful impact. The hardness of diamond contributes to its suitability as a gemstone. Because it can only be scratched by other diamonds, it maintains its polish extremely well. It is chemically resistant and is the only gem composed of a single chemical element i. e. carbon. Only two impurities such as boron and nitrogen are reported to be found in diamond. Diamonds have a light tint; usually yellowish or brownish colour. Diamond's ignition point is 720 - 800 °C in oxygen and 850 - 1,000°C in air.

Diamond in kimberlitic rock

Diamond
in gem
form



As far as occurrence is concerned, diamonds are not found on Earth's surface. Most natural diamonds are formed at high-pressure high-temperature conditions existing at depths of 140 to 190 kilometers (87 to 120 miles) in the Earth mantle. Carbon-containing minerals provide the carbon source and the growth occurs over periods from 1 billion to 3.3 billion years (25% to 75% of the age of the earth). Diamonds are brought close to the earth surface through deep volcanic eruptions by a magma, which cools into igneous rocks known as kimberlites and lamproites. These rocks in India are mainly found in Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Karnataka and Orissa. In Andhra Pradesh mostly found in Cuddapah, Anantapur, Bellary, Kurnool, Kistna, Godavary and Guntur districts. In Madhya Pradesh Panna and Majgawan districts. The diamonds average production in India is about 2150 carat per year.

Diamonds are thought to have been first recognized and mined in India, where significant alluvial deposits of the stone could be found many centuries ago along the rivers Penner, Krishna and Godavari. There are a limited number of commercially viable diamond mines currently operating in the world. In Asia they are in Russia and India. In India they are in Golkonda, Kollur Mine, Panna, and Chhatarpur (Madhya Pradesh). Roughly 49% of diamonds originate from Central and Southern Africa, although significant sources of the mineral have been discovered in Canada, India, Russia, Brazil, and Australia. The main agency, mining diamond is National Mineral Development Corporation Ltd (NMDC) in India. Wholesale trade and diamond cutting is limited to few locations only. In 2003, 92% of the world's diamonds were cut and polished in Surat, India. Other important centers of diamond cutting and trading are the Antwerp diamond district in Belgium, (where the International Gemological Institute is based) A. single company, De Beers controls a significant proportion of the trade in diamonds. They are based in Johannesburg, South Africa and London. The recent expansion of this industry in India, employing low cost labour, has allowed smaller diamonds to be prepared as gems in greater quantities than was previously economically feasible.

Though diamonds are extremely hard, they are brittle and can be split up by a single blow. Therefore, diamond cutting is traditionally considered as a delicate procedure requiring skills, scientific knowledge, tools and experience. Diamond cutting is the art, skill and, increasingly, science of changing a diamond from a rough stone into a faceted gem. The diamonds' surface cannot be wet by water but can be easily wet and stuck by oil. This property can be utilized to extract diamonds using oil when making synthetic diamonds. Nitrogen is by far the most common impurity found in gem diamonds and is responsible for the yellow and brown colour in diamonds. In order of rarity, yellow diamond is followed by brown, colourless, then by blue, green, black, pink, orange, purple, and red. Colour diamonds contain impurities or structural defects that cause the coloration, while pure or nearly pure diamonds are transparent and colourless.



Diamonds can also be produced synthetically in a high-pressure high-temperature process which approximately simulates the conditions in the Earth mantle. An alternative and completely different growth technique is chemical vapor deposition (CVD). However, special gemological techniques have been developed to distinguish natural and synthetic diamonds and diamond simulants. Above 1,700°C in vacuum or oxygen-free atmosphere, diamond converts to graphite; in air, transformation starts at ~700°C. Naturally occurring diamonds have a density ranging from 3.15–3.53g/cm³, with pure diamond close to 3.52g/cm³. Diamonds' chemical property is very stable. Under room temperature diamonds do not react with any chemical reagents including various kinds of acid and alkali. Diamonds' surface can only be oxidized a little by just a few oxidants under high temperature (below 1,000 °C). So acid and alkali can be used to refine synthetic diamonds. The majority of commercially available synthetic diamonds are yellow. Other colours may also be reproduced such as blue, green or pink, which are a result of the addition of boron or from irradiation after synthesis.

Diamonds have been adapted for many uses because of the material's exceptional physical characteristics. Unlike many other gems, it is well-suited to daily wear because of its resistance to scratching—perhaps contributing to its popularity as the preferred gem in engagement or wedding rings, which are often worn every day. Because diamonds are very hard they are often used as an abrasive. Most industrial diamonds are used for these purposes. Small particles of diamond are embedded in a saw blade, a drill bit or a grinding wheel for the purpose of cutting, drilling or grinding. They might also be ground into a powder and made into a diamond paste that is used for polishing or for very fine grinding. In addition, diamond exhibits highest thermal conductivity amongst minerals and has high electrical resistivity making it suitable for application in semiconductors. Some blue diamonds are natural semiconductors, in contrast to most diamonds, which are excellent electrical insulators. The conductivity and blue colour originate from boron impurity.

Diamond is the most important gemstone in the jewellery industry. The colourless stone is most often used for jewellery, although yellow and brown are also used. Diamond windows are made from thin diamond membranes and used to cover openings in lasers, x-ray machines and vacuum chambers. They are transparent, very durable and resistant to heat and abrasion. Diamond speaker domes enhance the performance of high quality speakers. Diamond is a very stiff material and when made into a thin dome it can vibrate rapidly without the deformation that would degrade sound quality. Heat sinks are materials that absorb or transmit excess heat. It is used to conduct heat away from the heat sensitive-parts of high performance microelectronics. Low friction microbearings are needed in tiny mechanical devices. Just as some watches have jewel bearings in their movements diamonds are used where extreme abrasion resistance and durability are needed. Wear-resistant parts can be produced by coating

surfaces with a thin coating of diamond. In this process, diamond is converted into a vapour that deposits on the surface of parts prone to wear. Diamond Bhasma is often prescribed by Ayurvedic practitioners because it is extremely powerful medicine, however, can only be taken under supervision of an experienced Ayurvedic medical practitioner.

Amethyst

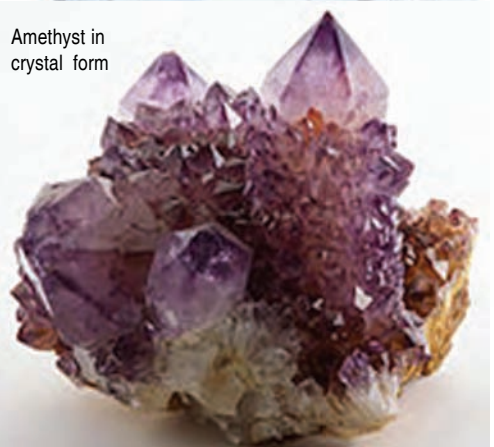
Amethyst is a well known mineral and gemstone. It is the purple, most valuable and prized variety of the mineral Quartz. Its name is derived from the Greek “Amethystos”, which means “not drunken”, as Amethyst in antiquity was thought to ward off drunkenness. The colour of some amethyst specimens from certain localities slowly fades upon prolonged exposure to light. When used as a gemstone, it is often heat treated to deepen the colour or to transform it into Citrine. Some varieties may also change to a light green colour, which is given the trade name Prasiolite, or Green Amethyst, as it is more commonly known in the gem trade.

In India amethystine quartz is found in the cavities and veins of some of the quartz reefs in Bundelkhand, Madhya Pradesh. Small amethysts occurring in Deccan Trap geodes are collected from the bed of Narmada river near Jabalpur and are used for jewellery and beads. Amethyst also occurs near Andar in Shivpuri and near Chitai, Gangari and Chandeva in Datia. In Andhra Pradesh, beautiful amethyst is found at Bowenpally near Secunderabad; it occurs in granites near Hyderabad and also about 96 km north of it at Bekonenpett. It is found at Koilkuntla in Kurnool. Geodes of quartz lined with crystals of amethyst occur near Burhait in Santal Parganas. Occurrence of amethyst has been reported from north of Kishangharh, Rondeil and Samod in Rajasthan. In Kangayam and Kollengode in Kerala and in Coimbatore. At several localities in Sutlej river valley in Himachal Pradesh and in Zaskar in Jammu and Kashmir. Its production data in India is not available for a long time.

Amethyst is famous for its purple colour but not all amethyst are purple in colour; they are also light purple, reddish-purple, bluish-purple, dark purple and even almost black in colour.



Amethyst in cavity form of rock



Amethyst in crystal form

Amethyst is famous for its purple colour but not all amethyst are purple in colour; they are also light purple, reddish-purple, bluish-purple, dark purple and even almost black in colour. The colouring agent of amethyst is iron. Top quality amethyst is a deep medium colour of purple with rose-colored flashes. In its purest form, amethyst is colourless and a fine amethyst is transparent which allows light passes through the gem unhindered while a translucent amethyst slightly weakens the passage of the light through the stone. Most amethyst pieces are cut into circular or round shapes. The chemical formula of amethyst is SiO_2 ; sp. gr., 2.65 and hardness, 7.

Synthetic amethyst is man-made by gamma-ray, x-ray or electron beam irradiation of clear quartz which has been first doped with ferric impurities. On exposure to heat, the irradiation effects can be partially cancelled and amethyst generally becomes yellow or even green and much of the citrine or yellow quartz of jewellery is said to be merely burnt amethyst. Synthetic amethyst is made to imitate the best quality amethyst. Its chemical and physical properties are so similar to that of natural amethyst that it can not be differentiated with absolute certainty without advanced gemmological testing (which is often cost-prohibitive). There is one test based on “Brazil law twinning” which can be used to identify synthetic amethyst rather easily.

As far as amethyst uses in rings and other jewellery items are concerned it is believed that amethyst have special properties, viz. it controls temper and emotions, protects drunker (it is believed that wearing amethyst while drinking wine would prevent the wearer from becoming drunk or being intoxicated). It improves the moral character of wearer, brings peace and calm in life and enhances spirit and energy to solve any difficulties and problems. It can save from deceit and protect people from baldness. It also improves the condition of skin of a person too. It is cut into studs and buttons.

Emerald (*Panna*)

Emeralds are the transparent and coloured varieties of beryl mineral and are much valued as precious stones. In Sanskrit it is known as *Marakatha*, in Persian as *Zamurrad* and in Hindi commonly called as *Panna*. Green coloured (green colour of the plantain leaf having a velvety sheen) are the fascinating emerald gemstones. Emerald word is coined on Persian word, *Esmeralde*. They have the most beautiful, most intense and most radiant green. The top quality, fine emeralds are even more valuable than diamonds. It is available in various colours like yellowish-green, bluish-green or blue. Its beautiful green colour, combined with durability and rarity, make it one of the most expensive gemstones. Deep green is costlier and most desired colour in emeralds. This gemstone is rare because it is very difficult to find a flawless emerald. Most emeralds are defective, having a feather - like crack and inclusions. To find an emerald that is of rich green color, perfectly transparent, with a velvety reflection and high specific gravity is difficult.

In the history of emeralds the earliest known area where the natural emerald was found is Red sea in Egypt. Later on it was found in Columbian mines. In fact, it is



Emerald in crystal form

Emerald as gemstone



Emerald in source rock



said that the beauty and quality of emerald gemstone that were found in Colombia was such that people at that time preferred suffering torture or even dying than to reveal the source of the mines. In India emerald is mainly found in Rajasthan, important producers being the Bubani and Rajgarh mines in Ajmer and Kalaguman and Tekhi mines in Udaipur district. In Orissa, the occurrences of emerald along with other gemstones had been identified over a tract extending from Birmaharajapura to Patangarh in Kalahandi district. It is also found in Karnataka, Andhra Pradesh, Tamil Nadu, Bihar and Jammu & Kashmir. In ancient times (about 4000 BC in Babylon, the oldest known gem market), fine quality emerald crystal gem was dedicated to the Goddess Venus. It is believed that this gem represents immortality and faith. In India the emerald gemstone is one of the Navagraha stones (stones that represent the nine planets that have a cosmic influence on all earthlings) representing the Mercury (Budh) and is related to business, communication, intelligence, education and intuition.

The chemical formula of Emerald is, $3\text{BeO} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$. It possesses Be, 12-13%; sp. gr., 2.6-2.8 and hardness (H), 7.5-8. The most common treatment carried out on emeralds to enhance the quality of the stone is oiling and using fillers along with the oil. The natural emerald crystal is soaked in colour as well as colourless oil or resins for a particular amount of time. Many a times the oil may be heated, so that it seeps well in the fractures of the gems. This helps to fill in emerald fractures to make it look like a less included gem and enhance its colour. Although oiling is an accepted trade practice, treatment with colour oil, resin or any other filler should be disclosed before selling, as it can drastically bring down the price.

Emerald gemstone had been synthesized in the laboratory several times by earlier scientists, but the first commercial synthetic emerald production was accomplished by Carroll Chatam around 1940. Cut gemstones of over 5 carats are commonly available in the market. The cost of synthetic emerald or lab created emerald is much lower than



the natural ones. Synthetics are invariably very transparent and have the best green colour. With the un-aided eye it is very difficult to distinguish the synthetic emeralds from the natural ones.

Emerald is mainly used in jewellery like rings, bracelets, nucleus and for preparing the decorative items, etc. High quality emeralds are used as ring stones and beads, while inferior qualities are used for idol carving. It is used for purification of blood and in urinary diseases and for some kinds of cardio-vascular diseases. Emerald is also useful in treatment of deaf and dumb. It is reported that emerald can be used to enhance the memory and stimulate the use of greater mental capacity. The emerald helps combine intelligence with discernment, allowing for the choice of right action.

Garnet

Garnet is the collective name for a group of minerals which forms an isomorphous series and crystallize in cubic system. Garnet word is derived from ancient Greeks since color reminded them of the pomegranate seed or Granatum. Garnets are actually one of the largest families of gemstones. Most natural garnets are mixtures of two or more of the following pure species: pyrope, almandine, spessartine, uvarovite, grossular and andradite. Garnets occur in a very wide variety of formations, colours and clarities.

Garnet is the name given to a group of chemically and physically similar minerals. A very small number of garnets are pure and flawless enough to be cut as gemstones. It is a silica mineral; in other words, garnet's complex chemical formula includes the silicate molecule $[A_3B_2(SiO_4)_3]$, sp. gr., 3.2-4.3]. The different varieties of garnet have different metal ions, such as iron, aluminum, magnesium and chromium; a few varieties also have calcium. It can be translucent to transparent, sometimes opaque with a vitreous or resinous lustre. All garnets are hard, ranging between 6 and 7.5 on the Mohs' hardness scale. They also lack cleavage, so when they break, they fracture into sharp, irregular pieces.

Garnet is a common mineral of metamorphic rocks such as gneiss and schist of all description from basic to acid, crystalline limestone and pegmatites. In India, garnet deposits suitable for use in abrasive industry, occur in Andhra Pradesh, Chhattisgarh, Jharkhand, Kerala, Orissa, Rajasthan and Tamil Nadu. Gem variety of garnet occurs in



Garnet in source rock

Ajmer, Jaipur, Kishangarh Tonk and Udaipur districts, Rajasthan, Krishna, Nellore and Warangal districts, Andhra Pradesh and Coimbatore, Nilgiri and Salem districts, Tamil Nadu. Garnet also occurs in beach sands along with ilmenite, rutile, sillimanite, etc. in the states of Kerala, Orissa and



Garnet in crystal form

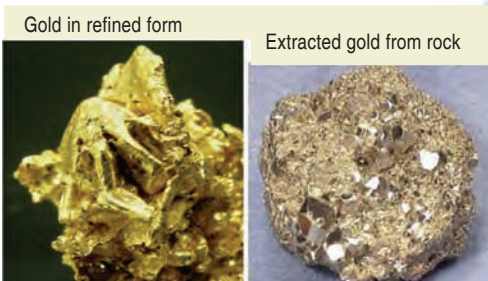
Tamil Nadu. Production of garnet (abrasive) is reported to be 873 thousand tonnes during 2007-08 and it has increased by 2% as compared to that in the preceding year. There were 49 mines during 2007-08 as against 48 in the previous years.

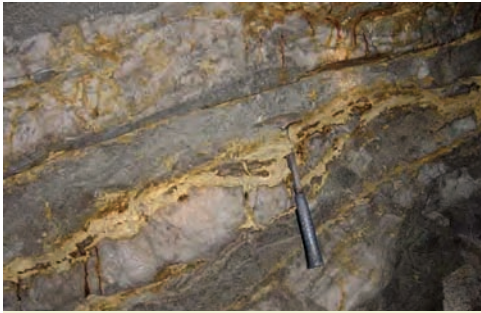
Garnet is hard with sharp angular chisel-edged fracture containing small amounts of free silica and exhibits high resistance to physical and chemical attacks. It is a resistant mineral and detritus grains are commonly found in sediments. It is used both as semi-precious stone and as abrasive. Garnet sandpaper was the original application of this mineral. It is also used to make a number of similar products, including sanding belts, discs and strips. Today, majority of garnet is used as an abrasive blasting material, for water filtration, in a process called water jet cutting. Garnet is also used in electronic components, ceramics, glass, jewellery and abrasives used in wood furniture and transport manufacturing. It is a common metamorphic mineral that becomes abundant enough to mine in a few rocks. Garnet forms used in industries are: reddish-orange, spessartine, yellow grossular and the green tsavorite and demantoid.

Gold

Gold, known as *Sona* in Hindi and *Swarna* in Sanskrit, is one of the most popular and well-known minerals, known for its value and special properties since ancient time. Gold in its natural mineral form, almost always has traces of silver and may also contain traces of copper and iron. Gold is a bright yellow metal with resplendent lustre. It is exceedingly malleable and ductile. Gold is one of the heaviest minerals, when pure, it has a specific gravity, 19.32, hardness 3 and melting point 1063°C. Due to its weight,

it can be panned because the gold sinks to the bottom. In addition, it can be easily separated from other substances due to the weight differences. Chemical formula of gold is Au. It is not acted upon by water or the atmosphere and good conductor of electricity.





Gold in source rock

Gold had a significant historical role in Australia, which had its first gold rush in 1851 after the mineral was found near Bathurst in New South Wales. The Bathurst gold rush was followed by discoveries in Victoria. Gold fever drew tens of thousands of immigrants from many parts of the world to the Australian colonies. Ballarat and Bendigo in Victoria

became sites of major rushes. Later, in the early 1890s, great finds were at Coolgardie and Kalgoorlie in western Australia. In India gold occurs in some states and mode of occurrence is two forms, first is through the placer deposits and second is source of rock deposits. The resources include placer-type gold ore in Kerala, Bihar, Karnataka, Rajasthan, West Bengal, Andhra Pradesh and Madhya Pradesh, while in terms of metal content, Karnataka remained on top followed by Rajasthan, West Bengal, Bihar and Andhra Pradesh. Total production of gold (primary & secondary) in 2007-08 is reported to be 2,858 kg. Main agencies which are working for gold exploration in India are: GSI, MECL, HGML, NMDC and DMG.

Gold usually occurs in its metallic state, commonly associated with sulphide minerals such as pyrite, but it does not form a separate sulphide mineral itself. The only economically important occurrence of gold in chemical combination is with tellurium as telluride minerals.

Native gold is found in the quartz of veins cutting through granite and schistose rocks, commonly associated with sulfides such as pyrite, chalcocopyrite, sphalerite, galena, stibnite, cinnabar and arsenopyrite. Non metallic gangue minerals include limonite and calcite. As a placer it is found in the gravels and sands of rivers whose channels cut through regions of quartz of veins and in the sands of beaches bordering gold-producing districts. In placers it is associated with heavy minerals which accumulate with it.

Gold is used in dentistry and medicine, jewellery and arts, medallions and coins and in ingots. It is also used for scientific and electronic instruments, computer circuitry, as an electrolyte in the electroplating industry and in many applications for the aerospace industry.

Onyx (Akik, Gomed)

Onyx is common semi-precious silica mineral, commonly known as *Akik* in Hindi and *Gomed* in Sanskrit. It is a banded variety of Chalcedony Quartz usually black or brown with white bands but can also be found in orange, red or honey colour. The name of this stone seems to have come from the Greek word Onyx which means finger nail or



Onyx in rock

claw. It occurs in bands of varying colour and transparency. It is cryptocrystalline quartz, milk-white, yellowish, reddish, brownish, greyish or delicate blue in colour and translucent to opaque with a waxy or greasy lustre. The colour may vary within the same stone and bands run parallel to each other but are often curved or concentric; they may be straight, wavy or zig-zag. The porosity of the layers in banded agate facilitates artificial colouring.



Onyx as gemstone

Onyx with other varieties of silica occurs as secondary infillings or geodes in ancient volcanic rocks and is most commonly found in the rivers that drain the areas covered by such rocks. It has resulted from the deposits of silica being thrown out of solutions; the shape of the bands depends on the shape of the cavities. Onyx commonly occurs in the amygdaloidal flows of the Deccan trap and the Rajmahal trap and the chief sources of supply are the rivers that drain the areas covered by these rocks. The beds of the Krishna, Godavari and Bhima rivers and the plains of Bijapur in Karnataka are also the sources of onyx. Major states in which onyx is found are Andhra Pradesh, Karnataka, Bihar, Gujarat, Madhya Pradesh and Rajasthan. Generally onyx is found in natural form but its chemical formula, SiO_2 ; sp gr, 2.60; H, 7 has been determined to prepare artificial onyx.

Onyx is chiefly used in making various decorative items, frames and to some extent in ceramics and other industries. Now-a-days Onyx is commonly used in ornaments like necklaces, rings, amulets, ear-rings, brooches, wristlets, beads, etc and many other jewellery pieces. Indian onyx has been famous and known all over the world since practically the dawn of history. Onyx is widely used as an astrological gemstone and believed that this gemstone eliminates negative thinking in the wearer and also protects from negative influences and forces. This stone is effective in all Chakras and is used to treat heart, kidney and nerve and eye ailments. This stone is good for those who are under stress and especially for those who have trouble sleeping. This gem is also widely used for treating epilepsy, depression, bone marrow, blood disorders, glaucoma, teeth, bones and hair. This is a very good stone for business people.

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Quartz (*Sphatik*)

Quartz is known as *Sphatik* in Hindi. It is one of the most well-known minerals on earth. It occurs in all mineral environments and is the important constituent of many rocks. It is hard, brittle and transparent to opaque minerals with vitreous to greasy lustre, conchoidal fracture, rarely exhibiting cleavage. It is insoluble in all acids except hydrofluoric acid. Quartz is colourless when pure but it is generally met with in tints of red, orange, yellow, green, violet and black, depending on the nature of inclusions. Many tints disappear on heating. One of the quartz minerals, the rock crystal, possesses piezo-electric properties.

Quartz is the most abundant and widely distributed mineral found at Earth's surface. It is present and plentiful in all parts of the world. It occurs at all temperatures and abundant in igneous, metamorphic and sedimentary rocks. It is highly resistant to both mechanical and chemical weathering. This durability makes it the dominant mineral of mountaintops and the primary constituent of beach, river and desert sand. Quartz is ubiquitous, plentiful and durable. Movable deposits are found throughout the world. Quartz occurs in abundance in most parts of the India in many states like Gujarat,



Quartz in crystal form

Rajasthan, Orissa, Madhya Pradesh, Andhra Pradesh, Bihar, Assam and Karnataka. Because of its abundance and distinctive crystal shape, quartz has been recognized as a mineral for thousands of years. The name has an uncertain origin, possibly derived from the German word Quarz, a word of ancient and uncertain origins. When it is water-clear, quartz is known as rock crystal or mountain crystal. However, quartz can contain a number of different impurities, which create different colour varieties. Purple quartz is known as amethyst; white is milky quartz;

black is smoky quartz; pink is rose quartz and yellow or orange is citrine. The molecular formula of quartz is SiO_2 , sp. gr. 2.60-2.66 and hardness is 7.

Most of the quartz used in microelectronics is produced synthetically. Large, flawless and untwined crystals are produced in an autoclave via hydrothermal process. The process involves treating crushed natural quartz with hot aqueous solution of a base such as sodium hydroxide. The hydroxide serves as a mineralizer, i.e. it helps dissolve the nutrient quartz. High temperatures are



Quartz in source (granite) rock

required, often around 675°C. The dissolved quartz then recrystallizes at a seed crystal at slightly lower temperatures.

There are two entirely different major uses for quartz crystal. One of these is as a gemstone. The varieties known as rock crystal, amethyst, smoky quartz, rose quartz and citrine are in demand as low-priced but attractive gemstone or display specimens. For gem applications, the quartz is usually cut and faceted for jewellery or is carved into various shapes by hand or by laser. Cultured quartz is used in electronic applications where its special physical properties are valuable. Quartz is one of several minerals which are piezoelectric, meaning that when pressure is applied to quartz a positive electrical charge is created at one end of the crystal and a negative electrical charge is created at the other. It is also strongly pyroelectric which means that temperature changes can cause the development of positive and negative charges within the crystal. These properties make quartz valuable in electronics applications. While some other minerals may have these properties, quartz is used because it is transparent, tough and of unvarying chemical composition. Electronics-grade manufactured quartz is used in a large number of circuits for consumer electronics products such as computers, cell phones, televisions, radios, and electronic games, to name just a few. It is also used to make frequency control devices and electronic filters that remove defined electromagnetic frequencies. In industry, quartz is also used in a variety of electronic devices. The production of quartz is reported to be 265 thousand tonnes in 2007-08.



Quartz in ornaments

Ruby (Manak, Lal)

Ruby is commonly known as *Manak* or *Lal* in Hindi. It is the transparent red-coloured variety of corundum mineral. The word corundum is derived from the Sanskrit word 'kuruvinda' and in Sanskrit ruby stands for '*Ratnaraj*', which means something like 'king of the gemstones'. History says that whenever a particular beautiful ruby crystal was found, the rulers sent high dignitaries out to meet the precious gemstone and welcome it in appropriate style. Today, rubies still decorate the insignia of many royal households.

Ruby word is derived from Latin word 'rubens', meaning 'red', Ruby-red. The most important thing about this precious stone is its colour. Two magical elements are associated with the symbolism of this colour: fire and blood, implying warmth and life for mankind. Like no other gemstone, the ruby is the perfect way to express powerful feelings. Its colour varies from deep red or



Ruby in source rock



Ruby in source rock



Ruby in crystal and gem form

pigeon's blood red through various shades to pink. The deep coloured varieties are strongly pleochroic from deep red to pale red. Ruby is distinguished for its bright red colour, being the most famed and fabled red gemstone. Besides, its bright colour, it is a most desirable gem due to its hardness, durability, luster and rarity. Transparent rubies of large sizes are even rarer than diamonds and ruby is found in hexagonal prisms and blades forms. For thousands of years, the ruby has been considered one of the most valuable gemstones on Earth. It has everything a precious stone should have i. e. magnificent colour, excellent hardness and outstanding brilliance. In addition to that, it is an extremely rare gemstone, especially in its finer qualities. The ruby, which sprays out red rays in the sunlight and glow in darkness is considered a superior quality gemstone. Ruby when rubbed on a stone and the stone shows signs of rubbing and also the ruby does not lose its weight, it is considered to be of a superior quality. The chemical formula for ruby is, Al_2O_3 , sp. gr., 3.9-4.1 and its hardness (H) is 9.

In India ruby is found in many states, viz. Andhra Pradesh (Anantapur, Krishna, Kurnool districts), Bihar (Manbhum district) and Tamil Nadu (Kangayam). Facet-grade ruby occurs in the Kangayam, Karnataka (Mysore) and ruby which is found in Channa, Patna area (Bihar) lacks transparency and so are suitable only for cabochons and beads. In the early 1980s, important gem strikes were made in Orissa, eastern India where ruby occurs in Jhillingdhar, Hinjhrilbahal, Charbati, Rabaandangar and Odashali and Karlakot in Kalahandi district and Sangamara in Balangir district

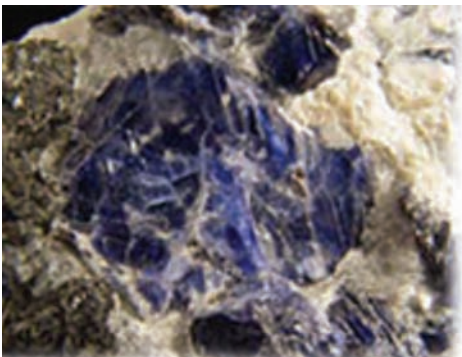
Like other precious minerals ruby is also a popular gemstones and is used extensively in jewellery. Ruby is used in all forms of jewellery, including bracelets, necklaces, rings and earrings. It is used both as centre piece gemstone in pendants and rings, as well as a secondary stone to complement other gemstones such as diamonds. Large ruby gems are extremely rare and valuable. Fine colour ruby with a deep red colour and excellent transparency can reach several thousand dollars a carat. Synthetic rubies are inexpensive and often used as a cheap substitute for natural rubies. Ruby is basically aluminium oxide and is used to treat anaemia or shortage of blood. It is also useful in treatment of low blood pressure and mental diseases. It strengthens nervous system and help fighting paralysis. It is also utilized for indigestion and gastric troubles. Ruby production in India was reported to be 5271 kg in 2005.

Sapphire (*Neelam*)

Sapphire, known as *Neelam* in Hindi, is the most precious and valuable blue gemstone and the variety of the mineral Corundum. Sapphire is the second hardest (first being diamond) natural mineral known to science. It is a very desirable gemstone due to its excellent colour, hardness, durability and lustre. When it is in other than blue colour i.e. red or dark pink, it is called ruby which is considered a different gemstone. Crystals of sapphire are transparent to translucent. Sapphires are found in typical six-sided barrel shape forms that may taper into a pyramid.

An exotic type of sapphire, known as colours changing sapphire, displays different colours depending on its lighting. In natural light, colours changing sapphire is blue, but in artificial light, it is violet. Yellow and pink Sapphire have recently become very popular and are now often seen in jewellery. Other optical properties like refraction and dispersion are the same as those for ruby. In trade all precious corundum other than red is generally called sapphire, but the varieties other than the blue (true sapphire) are known by separate names, viz. white sapphire, yellow sapphire (oriental topaz), green sapphire (oriental emerald) and purple sapphire (oriental amethyst). The hardness of sapphire can be partially attributed to the strong and short oxygen-aluminium bonds. These bonds pull the oxygen and aluminium atoms close together, making the crystal not only hard but also quite dense. The chemical formula of sapphire is Al_2O_3 , sp. gr. 3.9-4.1 and hardness (H.) is 9.

It occurs in feldspathoid-bearing igneous rocks as an accessory mineral, in recrystallized limestone, in placer sands and in aluminium-rich metamorphic rocks. Imitations of the sapphires are made by a flame fusion process and are so realistic that only experts can tell the difference. Synthetic sapphires are in great demand in industry, where they are used in movements of clocks, ballpoint pens and even in high temperature furnaces.



Sapphire in source rock



Sapphire as gemstone



Sapphire is found worldwide, Myanmar (Burma), Southeast Asia and Australia being major places of their occurrence. In India it is found in Kashmir, Orissa, Punjab and some amount in Madhya Pradesh. The sapphire-bearing rocks are now supposed to have a wider distribution in this region than was hitherto known. Ruby, aquamarine, beryl, rubellite, green tourmaline and garnet also occur in association of sapphire. The Kashmir sapphires are light blue to deep azure or sky blue in colour in the natural state. Orissa corundum is reported from Nilgiri hills on the North east border of Cuttack district, Bhujipadar and Ghumur-Sargigunda belts in Kalahandi district, Orissa. Punjab sapphires are reported to have been found on the ascent to Hamta pass (32° 16', 77° 26') in Kulu, Kangra district. The ratio of corundum sapphire to crude rock as mined has been estimated to be 1: 20.

Sapphire is one of the most popular gemstones, and is used extensively in jewellery. Fine coloured sapphire with a deep blue colour and excellent transparency can reach several thousand dollars a carat. The blue variety is most often used in jewellery, but the yellow, pink and orange “fancies” have recently become very popular. Green and light blue sapphires are also known but are less commonly used in jewellery. Opaque Black Sapphire is also used as a minor gemstone. Recently scientists have found a great scope of sapphire commercialization because sapphires are found naturally by searching through certain sediments or rock formations and can be created synthetically too. These can be manufactured for industrial or decorative purposes in large crystal boules. Because of its remarkable hardness sapphire can be used in some non-ornamental applications, including infrared optical components, such as in scientific instruments; high-durability windows (also used in scientific instruments); wristwatch crystals and movement bearings, and very thin electronic wafers, which are used as insulating substrates in solid-state electronics. From astrological point of view sapphire or neelam or sauri ratna or shani priya is thought to have power of elevating ones status right from social life to professional life. It brings name, fame and wealth to its user. According to astrologist sapphire is a fastest acting gemstone, it shows its effect within 3 second, 3 minute, 3 hour or 3 days.

Silver

Silver known as *Chandi* or *Rupa* in Hindi and in Sanskrit as *Rupya*, *Sveta* or *Rajata* is one of the most famous precious metals and it is in use since last 6,000 years. Silver was named from the Old English (Anglo-Saxon) word *Seolfer*. This name is related to the German word *Silber* and the Dutch word *Zilver*. An early Latin name for this mineral was *Luna* which means moon, an allusion to its striking, bright luster. Silver has brilliant white colour and resistant to atmospheric oxidation. Silver is extracted mostly from silver ores, but considerable amounts are mined from Native Silver. Silver can be found pure but usually it is mixed with small amounts of gold, arsenic and antimony. A natural



Silver in source rock



alloy of gold and silver is known as Electrum and is usually classified as a variety of Gold. Silver does not dissolve in most of the solvents and won't react to oxygen or water. However, it has a detrimental reaction to sulfur and sulfides, which causes it to tarnish on exposed surfaces. Hydrogen sulfide (H_2S) is found in the atmosphere in small quantities and when silver is exposed to normal air it reacts to the hydrogen sulfide, causing the tarnish. Egg yolks, which contain sulfur compounds, should be kept away from silver. Several chemical coats are available to protect it from tarnish and certain polishes remove tarnish. The chemical formula of silver is Ag, sp.gr.,10.5, m.p.1000 °C and hardness 2.5.-3.

In India, there are no native silver deposits except the small and unique Bharak deposit of silver in Rajasthan. It occurs generally with lead, zinc, copper and gold ores and is extracted as a by-product from electrolysis or chemical methods. In India, the silver ore deposits which are primarily mined for silver and of any commercial importance have not been reported. Silver mostly occurs in the form of argentiferous lead-zinc ores. Some of the gold ores also contain a small percentage of silver. The argentiferous lead-zinc ores found in the Zawar area in Rajasthan are the principal sources of silver in the country. The Zawar deposit occurs in a group of 10-12 hills with many ancient mine workings. Extensive and deep workings occur in Mochia Mangra, Baror Mangra



Silver articles and ornaments



and Zawar Mala hills. The ore consists mainly of argentiferous galena and sphalerite, associated with pyrite, arsenopyrite, chalcopyrite, quartz and crystalline dolomite. A sample assayed contained c. 300 g. of silver per tonne of lead. Silver ores of Kolar and Hutti mines, Mysore also contain small amounts of silver in Karnataka and in other state like Jharkhand, Uttarakhand, Orissa, Meghalaya, Sikkim, Tamil Nadu and Maharashtra also have some deposits. The lead ores of Andhra Pradesh, Bihar, Gujarat, Jammu & Kashmir and Uttar Pradesh are also reported to contain a fair amount of silver. However, these deposits have not been proved to be of potential value so far.

Silver has many unique physical properties that give it very special status. It is the best conductor of electricity and is the second most malleable and ductile metal and is in greater abundance than all other precious metals with similar properties. Due to its unique properties and intrinsic beauty, it is extensively used industrially and for preparing ornaments. Silver is largely used as jewellery and coins. It is very easy to work with it hence, beautiful objects such as goblets, candelabras, trays and cutlery are created. In the industrial sector, silver is widely used for electrical apparatuses and circuits. It is also used for medicinal purposes, particularly in dentistry, for bactericides and for antiseptics. It is reported that in 2007-08, the production of silver was 80,684 kg in India.

“The Wealth of India” – what a vision of past history and splendour it brings, when the Indies attracted adventurers in search of wealth and fortune from the most distant countries! Nevertheless, India is wealthy and the wealth of India is there. But in spite of this wealth, the people are poor. The problem for us is to utilize this stored-up wealth of the country in the soil and under the soil, for the benefit of Indian humanity. This book is a kind of encyclopaedia or dictionary, and dictionaries seldom make attractive reading, but I have found this particular dictionary rather fascinating and it has opened out vistas of thought to me. The pictures are good.

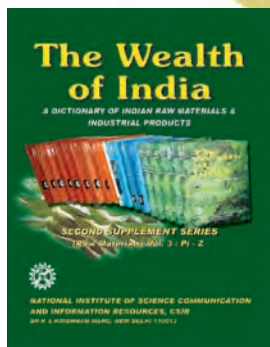


I have no doubt that this book, produced by many scholars and experts and after much labour, will be of great value to the builders of new India. It should be of value also in educating the average citizen, who should take interest in this fascinating land and its enormous potentialities.

New Delhi
21st December 1948

Jawaharlal Nehru
Jawaharlal Nehru

The National Institute of Science Communication and Information Resources (NISCAIR), a constituent of Council of Scientific and Industrial Research (CSIR), has been involved in dissemination of information for S&T community through its various scientific books, journals and magazines. *The Wealth of India*, launched in 1942 is an internationally acclaimed encyclopaedic publication comprising monographic articles on plants, animals and mineral resources of the country and the economic products derived from them. The encyclopaedia is a continuation of George Watt's Dictionary of Economic products of India. The complexity, heterogeneity and voluminousness of this encyclopaedic work can be visualized from the fact that whole series covers more than 6000 plant-species, 49 articles on animals and their products and 74 articles on minerals. The Wealth of India-Raw materials is indispensable to research workers especially beginners dealing with life sciences, chemical sciences, pharmacology, environmental sciences, students of economic botany, and gewloqy government departments and rural development agencies, planners, industrialists and all those interested in the availability of Indian raw materials, their production , value addition, exports and imports.



For detailed information on 10 precious minerals presented in this bulletin and others having varied importance and uses can be obtained from respective volumes of Wealth of India. The volume wise arrangement, geological names and their synonyms are enlisted in table given below

A TO Z OF MINERALS IN THE WEALTH OF INDIA-RAW MATERIAL SERIES

S. No.	Name of Minerals	Synonyms (Keywords)	Wealth of India Volumes
1	Agate	Akik, Chalcedony, Gomed, Onyx, Sardonyx	Vol.1 A
2	Alkaline Earths	Choulu, Crude Netural Soda, Khari, Ooverman, Ozhaiman, Phuli, Reh, Sajji Matti, Soudu	Vol.1 A
3	Alum	Aluminite, Alunogen, Kalinite	Vol.1 A
4	Antimony Ores	Anjana, Anjanam, Shurma, Stibnite, Surmah, Surmo	Vol.1:A
5	Arsenic Ores	Artal, Horital, Hartal, Hari-Tala, Orpiment, Pinda	Vol.1:A
6	Asbestos	Kalnar, Ratinarra, Sangresha, Shankha Palita	Vol.1:A; First Suppl Ser. Vol. 1: A-Ci



7	Barium Minerals	Barite, Barytes, Kolakkal, Mugge Rayi	Vol.2 B; First Suppl Ser. Vol. 1: A-Ci
8	Bauxite	Hydrated Aluminium Oxide	Vol.2 B; First Suppl Ser. Vol. 1: A-Ci
9	Bentonite	Mait, Mund-Dhoni Matti, Serati Matti, Seri	Vol.2 B
10	Beryl	Aluminus silicates, Beryllium	Vol.2B; First Suppl Ser. Vol. 1: A-Ci
11	Bismuth Ores	Bismuthinite, Bismuth Glance, Bismite	Vol.2 B; First Suppl Ser. Vol. 1: A-Ci
12	Borax	Boron, Elaegaram, Sohaga Tineal, Sohaga, Tankankhar, Vengaram	Vol.2:B; First Suppl Ser. Vol. 1: A-Ci
13	Building Stones		Vol.2:B; First Suppl Ser. Vol. 1: A-Ci
14	Cadmium	Cadmia, Calamine (Zinc carbonate)	Vol.3 (Ca-Ci); First Suppl Ser. Vol. 1: A-Ci
15	Calcite	Calc Spar	Vol.3 (Ca-Ci); First Suppl Ser. Vol. 1: A-Ci
16	Chromite	Chrome, Chromium	Vol.3 (Ca-Ci)
17	Chrysoberyl	Alexandrit, Chrysolite, Lahasumya	Vol.3 (Ca-Ci); First Suppl Ser. Vol. 1: A-Ci
18	Clays	Alumino silicate	Vol. II (C); First Suppl Ser. Vol. 2: Cl-Cy
19	Coal	Koela	Vol. II (C)
20	Cobalt	Hydrated Iron-Oxide	Vol. II (C); First Suppl Ser. Vol. 2: Cl-Cy
21	Copper Ores		Vol. II (C)
22	Corundum	Korund	Vol. II (C)
23	Diamond	Hira, Hirak, Vajra	Vol.III (D-E)
24	Dolomite		Vol.III (D-E)
25	Emerald and Aquamarine	Marakatha, Panna, Zamurrad	Vol. III (D-E); First Suppl Ser. Vol. 3: D-I
26	Felspar	Feldspar	Vol. IV (F-G); First Suppl Ser. Vol. 3: D-I

27	Fluorite	Fluorspar	Vol. IV (F-G); First Suppl Ser. Vol. 3: D-I
28	Fuller's Earth	Multani mitti	Vol. IV (F-G)
29	Garnet	Almandine, Almandite, Andratite, Colophonite, Grossular, Grossularite, Melanite, Pyrope, Rhodolite, Schorlomite, Spessaritine, Spessartite, Uvarovite	Vol. IV (F-G); First Suppl Ser. Vol. 3: D-I
30	Glass Sand		Vol. IV (F-G)
31	Gold	Sona	Vol. IV (F-G)
32	Graphite		Vol. IV (F-G)
33	Gypsum	Alabastar, Satin-spar, Selenite Suppl Ser.	Vol. IV (F-G); First Vol. 3: D-I
34	Iron Ores	Hematite, Ilmenite, Laterite, Limonite, Magnetite, Pyrite, Siderite	Vol. V (H-K)
35	Jade	Jadeite, Nephrite Suppl Ser.	Vol. V (H-K); First Vol. 4: J-Q
36	Kyanite		Vol. V (H-K); First Suppl Ser. Vol. 4: J-Q
37	Lead ores	Anglesite, Cerussite, Galena, Jamesonite, Pyromorphite, Zinkenite	Vol. VI (L-M)
38	Lignite		Vol. VI (L-M)
39	Limestone		Vol. VI (L-M)
40	Lithium mineral	Amblygonite, Lepidolite, Lithiophilite, Petalite, Spodumene, Zinnwaladite	Vol. VI (L-M); First Suppl Ser. Vol. 4: J-Q
41	Magnesite		Vol. VI (L-M)
42	Manganese ores	Braunite, Mangnit, Psilomelane, Pyrolusit	Vol. VI (L-M)
43	Mica	Biotite, Muscovite, Paragonite, Phlogopite	Vol. VI (L-M)
44	Mineral spring		Vol. VI (L-M)
45	Molybdenum ores	Wulfenite	Vol. VI (L-M); First Suppl Ser. Vol. 4: J-Q
46	Monazite		Vol. VI (L-M)
47	Nickel ores	Garnierite, Niccolite, Nickeliferous pyrrhotite, Pentlandite	Vol. VII (N-Pe); First Suppl Ser. Vol. 4: J-Q
48	Nitre	Patluppu, Pottiluppu, Shora	Vol. VII (N-Pe)
49	Petroleum and Natural Gas	Crude oil, Hydrocarbon, Mineral oil, Natural oil	Vol. VII (N-Pe)



50	Phosphatic Minerals	Apetite, Cellophane, Phosphates Triplite, Vivianite	Vol. VIII (Ph-Re)
51	Pigment Minerals		Vol. VIII (Ph-Re); First Suppl Ser. Vol. 4: J-Q
52	Platinum Mineral	Iridium, Palladium, Rhodium, Ruthenium, Safed sona	Vol. VIII (Ph-Re); First Suppl Ser. Vol. 4: J-Q
53	Quartz & Silica	Amethyst	Vol. VIII (Ph-Re)
54	Rare Earths		Vol. VIII (Ph-Re)
55	Road Metals	Road stone	Vol. IX (Rh-So); First Suppl Ser. Vol. 5: R-Z
56	Salt	Halite, Khanij namak, Lahori namak, Lavanam, nimak, Rock salt, Saindhava namak, Uppu	Vol. IX (Rh-So); First Suppl Ser. Vol. 5: R-Z
57	Sands		Vol. IX (Rh-So); First Suppl Ser. Vol. 5: R-Z
58	Sillimanite		Vol. IX (Rh-So); First Suppl Ser. Vol. 5: R-Z
59	Silver Ores	Chandi, Chandi rupa, Rupya, Sveta, Rajola, Tara, Velli	Vol. IX (Rh-So); First Suppl Ser. Vol. 5: R-Z
60	Spinel		Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
61	Steatite & Talc	Pyrophyllite	Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
62	Strontium Minerals	Celestite, Stronlinate	Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
63	Sulphur & Pyrites	Avala sara, Gandhaka, Gandhaka, Phule, Gandrok, Pyrite, Sadha gandhaka	Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
64	Tantalum & Niobium Ores		Vol. X (Sp-W)
65	Tin Ores	Cassiterite, Tin stone, Kallai ranga, Ranga, Kathal, Tagaramu, Vanga ranga	Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z

66	Titanium Minerals	Ilmenite, Rutile	Vol. X (Sp-W)
67	Topaz	Fushparaga, Pukhraj, Pushpa Raagannu	Vol. X (Sp-W)
68	Tourmaline Ores	Turmali	Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
69	Tungsten ores	Scheelite, Wolframite, Wolfram	Vol. X (Sp-W)
70	Uranium Ores	Autunite, Brannerite, Carnotite, Coffinite, Davidite, Pitchblende, Torbernite, Uraninite, Uranophane	Vol. X (Sp-W)
71	Vanadium Ores		Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
72	Vermiculite		Vol. X (Sp-W); First Suppl Ser. Vol. 5: R-Z
73	Zinc Ores	Franklinite, Hemimorphite, Smithsonite, Sphalerite zinc blend, Willemite, Zincite, Redoxite	Vol. XI (X-Z)
74	Zirconium Minerals	Zircon	Vol. XI (X-Z); First Suppl Ser. Vol. 5: R-Z





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