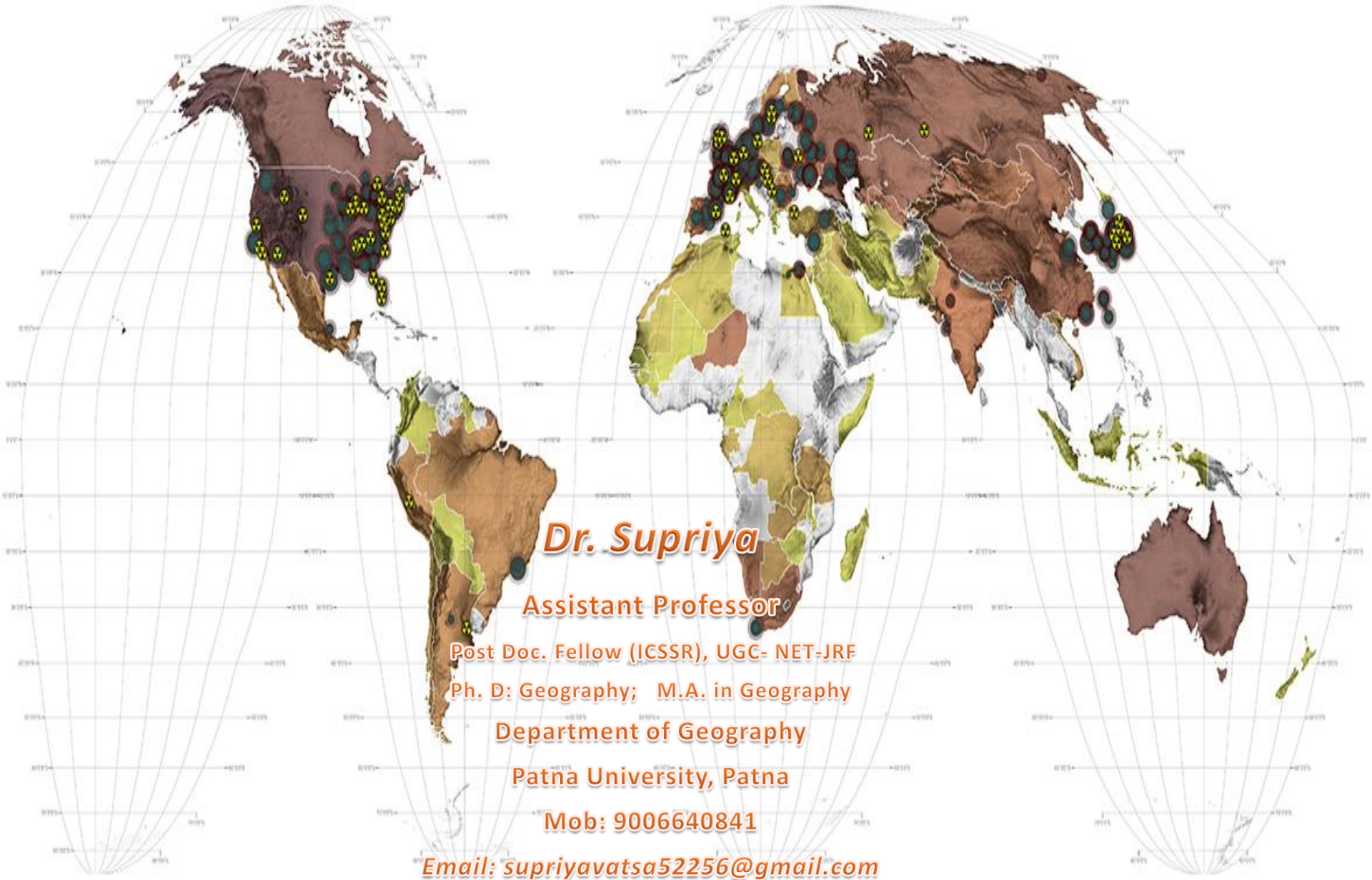
MA-SEM II (CC- India Unit –I)

Atomic Minerals



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- ✓ *Learning Objectives: To understand the classification, distribution and Production and uses of atomic minerals in the World*
- ✓ *Learning Outcome: able to explain characteristics, uses, location and production of different atomic minerals.*
- ✓ *Keywords: Radioactive, Uranium, Thorium, Lithium, Beryllium*

INTRODUCTION

- **Mineral is a naturally occurring inorganic substance, with fixed range in chemical composition, and is usually obtained by mining.**
- **Atomic minerals are the most important among non-fossil energy resources which are the minerals of radioactive elements like Uranium (U) and Thorium (Th).**
- **Atomic energy is produced by fission (splitting of the radioactive-elements like uranium) or by fusion (like colliding and fusing of two deuterons to form helium) of atomic nuclei, with matter being converted into energy in either process.**
- **Radioactivity was discovered in 1896 by the Henri Becquerel (1852-1908), Pierre and Marie Curie.**
- **Atomic Minerals are discrete minerals of Uranium and Thorium as uraninite (of U) and thorite (of Th). They also occur in notable quantity in mineral like of Rare Metals- Nobelium (Nb), Tantalum (Ta), Lithium (Li), Beryllium (Be), Zirconium- Zr, Sn, W etc).**
- Atomic minerals are broadly divided in two groups-

- **1. Primary minerals:** Those are formed directly from magmas, hydrothermal Solution and groundwater. Example- Uraninite, Thorianite.
- **2. Secondary minerals:** These are formed due to remobilization of elements from primary minerals, their transportation in solution and later precipitation due to oversaturation in oxidizing or supergene environment. Example- Thorogummite (Th, supergene environment).

- **Some example of Atomic minerals-** Autunite (Hydrated calcium uranium phosphate) , Brannerite (Uranium Titanate), Carnotite (Potassium Uranium Vanagate) , Monazite (A mixed REE & Th phosphate) , Thorianite (Thorium oxide) , Uraninite (Uranium dioxide) etc.

Occurrence of Atomic Minerals

They are predominately found in the form of Achaean Schist or Pre-Cambrian rocks and placer deposits in very low content in the world.

- **1. Magmatic or Igneous rocks** (~2ppm in the crust): In the magmatic rocks, they usually concentrate in acidic, plutonic rocks which include granitoids– pegmatite, and volcanic rocks like rhyollites and acid tuffs. Minerals like monazite and zircon also occur in placer derived from such magmatic rocks.
- **2. Sedimentary rocks:** Amongst the sedimentary rocks, sandstones, pyrite-bearing Quartz -pebble conglomerates and phosphatic and carbonaceous rocks are good hosts for uranium minerals.
- **3. Metamorphic rocks:** Low grade metamorphic rocks like phyllite and schist subjected to metasomatic alterations involving addition of volatiles within the structurally weak zones are loci for uranium minerals. Thorium minerals occur generally in acidic igneous rocks and high grade metamorphic rocks and placers derived from these rocks.
- **Uses of Atomic Minerals:** Nuclear Energy, Nuclear Power Plant, weapon, Military Purpose.

• Major Atomic Minerals in the World

- Uranium and Thorium are the main atomic minerals. Other atomic minerals are beryllium, lithium and zirconium.

Major Atomic Minerals in the World:

1. **URANIUM:** Uranium is most important atomic minerals in the world.

- Its Atomic Number is 92 and chemically represented by U.
- Uranium became most prominent source of atomic minerals used in atomic energy.
- Its radioactive reaction was discovered in 1896 while its existence in which plane was discovered in 1789. It was first used as a pigment in ceramics.
- **Characteristics of Uranium:**
- Uranium is the heaviest of the naturally occurring elements.
- It is highly radioactive chemically reactive and steel grey metallic element.
- There is several uranium bearing minerals which contains various amounts of Uranium oxide. The outstanding property of Uranium is found in U 235 which is fissionable in several isotopes by slow neutrons releasing an enormous amount of energy.
- Its principle isotope is U238 which can be transmitted to plutonium that is also high fissionable.
- **Types of Uranium Ore:** Uranium bearing minerals and ores are classified into two broad groups:

1. **Primary Mineral Ore:** It contains 50 to 80 % uranium oxides. Ex. Pitchblende
2. **Secondary Mineral Ore:** It contains 50 % uranium oxides. Ex. Coronate.

World distribution and production of Uranium:

- **World total output of Uranium 35.30 in 2002, which increases to 53,498 tones in 2018.**
- **Over two-thirds of the world's uranium production is from Kazakhstan, Canada and Australia.**
- Kazakhstan produces the largest share of uranium from mines (41% of world).
- An increasing amount of uranium, now over 50%, is produced by in situ leaching.
- After a decade of falling mine production to 1993, output of uranium has generally risen since then and now meets almost all the demand for power generation (83 % of total Atomic energy).
- **Uses of Uranium:** Nuclear energy, military purpose- nuclear weapon, ballistic ships, submarine, counter weights to aircraft etc.

Table: 1.1 Country-wise Reserves of Uranium in the World (2012)

SN.	Country	tones U	% of world
1	Australia	1,818,300	30%
2	Kazakhstan	842,200	14%
3	Canada	514,400	8%
4	Russia	485,600	8%
5	Namibia	442,100*	7%
6	S. Africa	322,400	5%
7	China	290,400	5%
8	Niger	280,000*	5%
9	Brazil	276,800	5%
10	Uzbekistan	139,200*	2%
11	Ukraine	114,100	2%
12	Mongolia	113,500	2%
13	Botswana	73,500*	1%
14	Tanzania	58,200*	1%
15	USA	47,200	1%
16	Jordan	43,500	1%
17	Other	280,600	4%
	World total	6,142,600	-

* Source: OECD NEA & IAEA, Uranium 2018: Resources,

- **Major Exporters:** Australia, Kazakhstan, Canada, Niger, South Africa.
- **Major Importers**: USA, Italy, Japan, France, Germany, India.

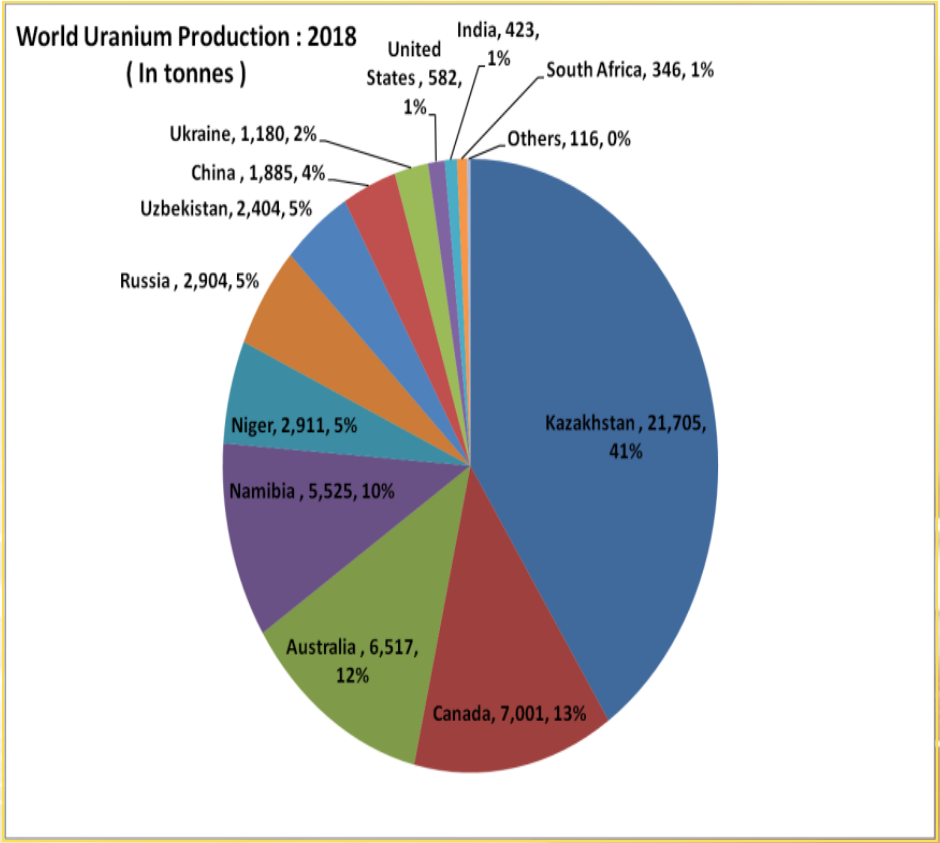
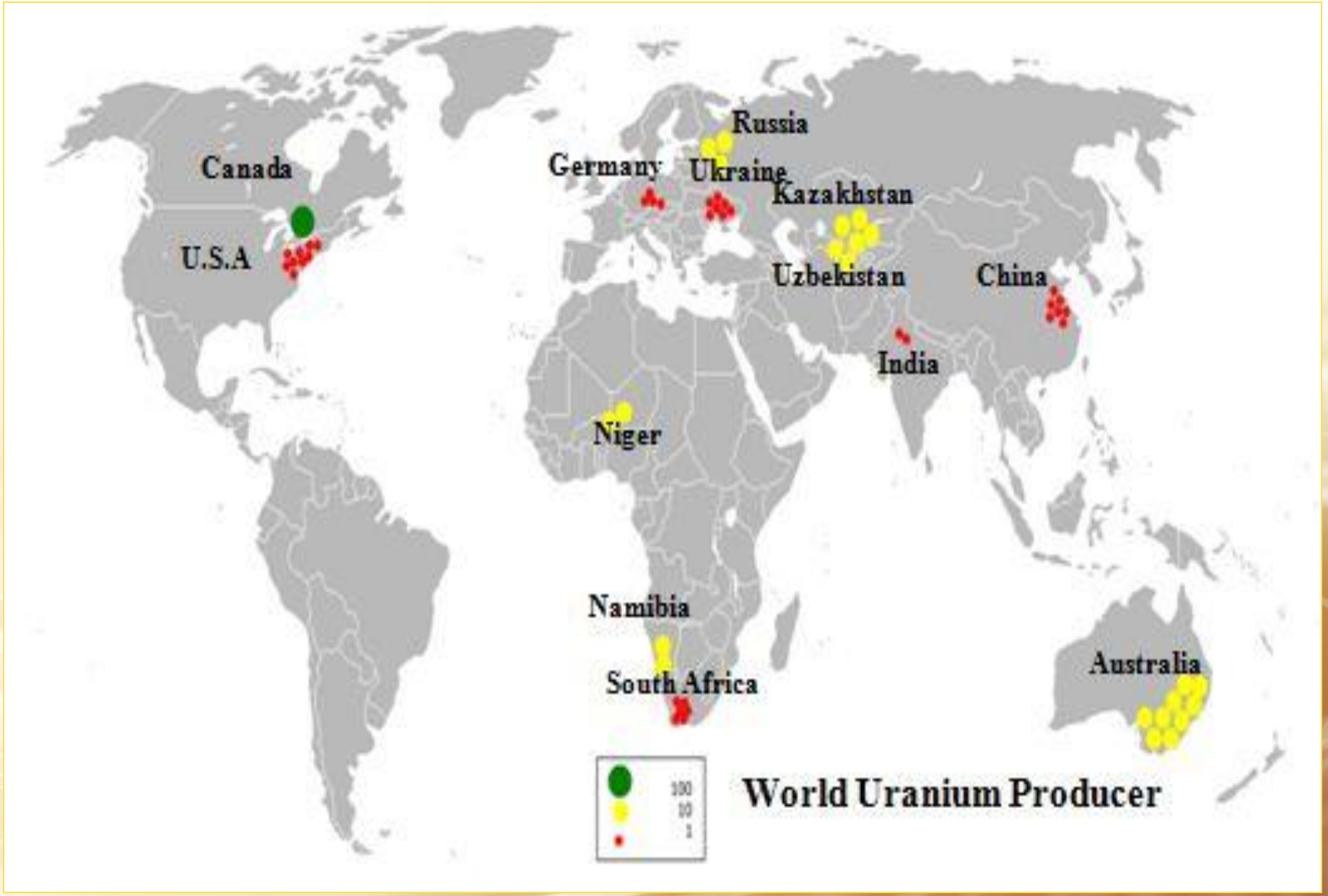


Table: 1.2 Country-wise Production of Uranium in the World (2018)

Sl.	Country	In tones	% of World
1	Kazakhstan	21,705	40.57%
2	Canada	7,001	13.09%
3	Australia	6,517	12.18%
4	Namibia	5,525	10.33%
5	Niger	2,911	5.44%
6	Russia	2,904	5.43%
7	Uzbekistan	2,404	4.49%
8	China	1,885	3.52%
9	Ukraine	1,180	2.21%
10	United States	582	1.09%
11	India	423	0.79%
12	South Africa	346	0.65%
13	Others	116	0.27%
	World	53,498	100.00%

** source: The Nuclear Fuel Report, 2019 (World Nuclear Association)*

Major uranium mining countries in the world



Major uranium mining areas of the world

1. **Kazakhstan:** Major deposits found in sandstone and limestone in the Farghana basin of southern Kazakhstan.
2. **Canada: Major uranium deposits found in Beaverlodge, Port Radium, Von Croft and Blind River; largest mines Cigar lake, Mc Arthur River.**
3. **Australia:** mined from Radium hill , South Australia & Rum Jungle mines; largest mines Ranger & Olympic dam.
4. **Namibia: Major mining areas- Rossing Mountain region, Langer Heinrich, Husab; largest mines Rossing mines**
5. **Niger:** Major mining areas- Air mountains of Agadez region, Imouraren-Areva.largest mines Akouta & Arlit.
6. **Russia: Major mining areas- Ural region. Largest Mines Krasnokamensk**
7. **Uzbekistan: Major mining areas- Ferghana basin.**
8. **U.S.A:** Major mining areas lies from Utah to Colorado Plateau. New Mexico, Wyoming, South Texas Nebraska, Brooks County are major producer.
9. **China**: Major areas are Hunan, Fujian, Shaanxi, Xinjian Province; Largest mines Chenxian.
10. **Ukraine:** Major areas-Kirvogaurd, Dnipropetrovsk Region
11. **South Africa:** Major areas- Vaal region of Johannsberg.
12. **India:** Major mining areas- Jadugorda , Jharkhand
13. **Malavi:** Major minning areas- Kayelekara mines of Karonga.

Other Minor Uranium producers: Congo, Gabon, France, United Kingdom, Chzech republic etc.

2. Thorium (Th)

- Thorium is weakly radioactive unstable element which is chemically expressed by 'Th', atomic number is 90 and the atomic weight 232.
- The radioactivity of thorium was discovered independently in 1898 by the physicist Marie Sklodowska - Curie and the chemist Gerhard C. Schmidt.
- **Characteristics:**
- **Thorium is silvery and tarnishes black when it is exposed to air, forming thorium dioxide.**
- Thorium is moderately hard, malleable, and has a high melting point (5972℉).
- All of its isotopes are radioactive. Stable known isotopes are 232. Alpha decay process and decay chain results stable isotopes 208 P**b (Lead)**
- **Thorium is rare metal (REM) which is equivalent to 14.05 billion year, primordial formation (before earth formation).**
- **Uses of Thorium:** Mostly used in high temperature resistant application- heat resistant crucibles, arc lighting element, high intensity lanterns, arc welding, weapon (fission bomb in 1950 in Use along with USA),nuclear energy, high end magnification lens used in scientific and photographic equipments due to excellent wavelength dispersion and refractive index etc.

3. Berllium (Be)

- **Characteristics:** Berillium is the rare earth element (REE) which is chemically represented by Be and Atomic number is 4.
- It is divalent element which occurs naturally with other element aquamarine emerald/ beryl, chrgsoberyl.
- Highly flexural rigidity, thermal stability, thermal conductivity and low density
- **Uses of Beryllium:**
- Aerospace and Spacecraft: radiation windows and rocket nozzles; desirable in aerospace material for missiles, spacecraft and satellites because of low density and atomic mass. The high thermal conductivities led to their use in thermal management applications.
- Healthcare: berylliums relatively transparent to X-rays and other forms of ionizing radiation; therefore, it is the most common window material for X-ray equipment and components of particle detectors.
- Alloying elements like aluminum, copper, iron, nickel improves its physical properties and tools made by beryllium alloy are hard and strong. Ex- Non sparkling tools, surgical instruments & precision Instruments
- Magnetic & Nuclear applications: Works as a neutron reflectors and moderators (Proton to neutron beam).
- Other uses like aquatic, electronics tools.
- **World Production: USA, china, Kazakhstan are the major producing whom has extracted beryllium for industrial purpose.**

4. Lithium (Li)

- Chemically expressed by Li, atomic number is 3.
- It is soft silvery white colour, low density and lightest solid element,
- Its a alkai metal which is highly reactive and flammable,
- It must be stored in mineral oil .
- The metal is found in brine (Brine is a high-concentration solution of salt in water)
- The metal is separated from other elements evaporation or electrolysis.
- **Uses:** Industrial application, heat resistant glasses, ceramic, grease, lubricants, flux additives for iron, steel and aluminium production, lithium ion batteries, drugs in several treatments, nuclear reactor coolants etc.
- **World production of Lithium:**
- Total production 85000 tones with 14 billion tones global reserve.
- South America is the largest producer of lithium
- **Australia:** largest producer with 51000 tones production
- **Argentina:** total production 6200 tones ; major mining area Arizaro.
- **Chile: total production 1600 tone; mining area Atacama region;**
- **Bolvia’ s Salar de Uyuni, Chile’ s Atacama and Argentina’ s Arizaro known as a lithium triangle and have 75 % of global reserve of the world.**
- Canada, Brazil, Zimbabe are othe minor producer of lithium.

5. Zirconium (Zr)

- **Zirconium: Zirconium is a chemically represented by Zr and atomic number is 40.**
- **Zirconium is found in 140 minerals, but Zircon, baddeleyite and kosnarite are commercially useful ores.**
- **Zircon is the prime source of Zirconium, which is, a gemstone, comes in blue, yellow, green, brown, orange, red and occasionally purple varieties.**
- **The word Zirocon comes from the Persian "zargun" which means gold color.**
- **It has been used in jewelry and other decoration for centuries.**
- **It is a malleable and ductile; easily forms stable compounds; highly resistant to corrosion.**
- **Uses of Zirconium Alloys:** Zirconium alloys can be found in pipes, fittings and heat exchangers, hardening agent in steel alloys, colored glazes, bricks, ceramics, abrasives, flashbulbs, lamp filaments, artificial gemstones and some deodorants, catalytic converters, furnace bricks, lab crucibles, surgical instruments, television glass, removing residual gases from vacuum tubes, treats poison ivy,
- **Largest mining country is Australia; United States, Brazil, South Africa, Russia, and Sri Lanka are other important producers**
- As of 2013, two-thirds of zircon mining occurs in Australia and South Africa

World zirconium reserves

(Data in thousand metric tons, ZrO_2)

Country	Reserves
United States	500
Australia	40,000
China	500
India	3,400
Indonesia	NA
Mozambique	1,100
South Africa	14,000
Other countries	7,200
World total	**67,000**

Source: USGS, 2014

World zirconium mine production

(Data in thousand metric tons)

Country	2012	2013
US	W	W
Australia	605	600
China	140	140
India	40	40
Indonesia	120	120
Mozambique	47	65
South Africa	383	360
Other countries	130	110
World total	**1,460**	**1,440**

Source: USGS, 2014

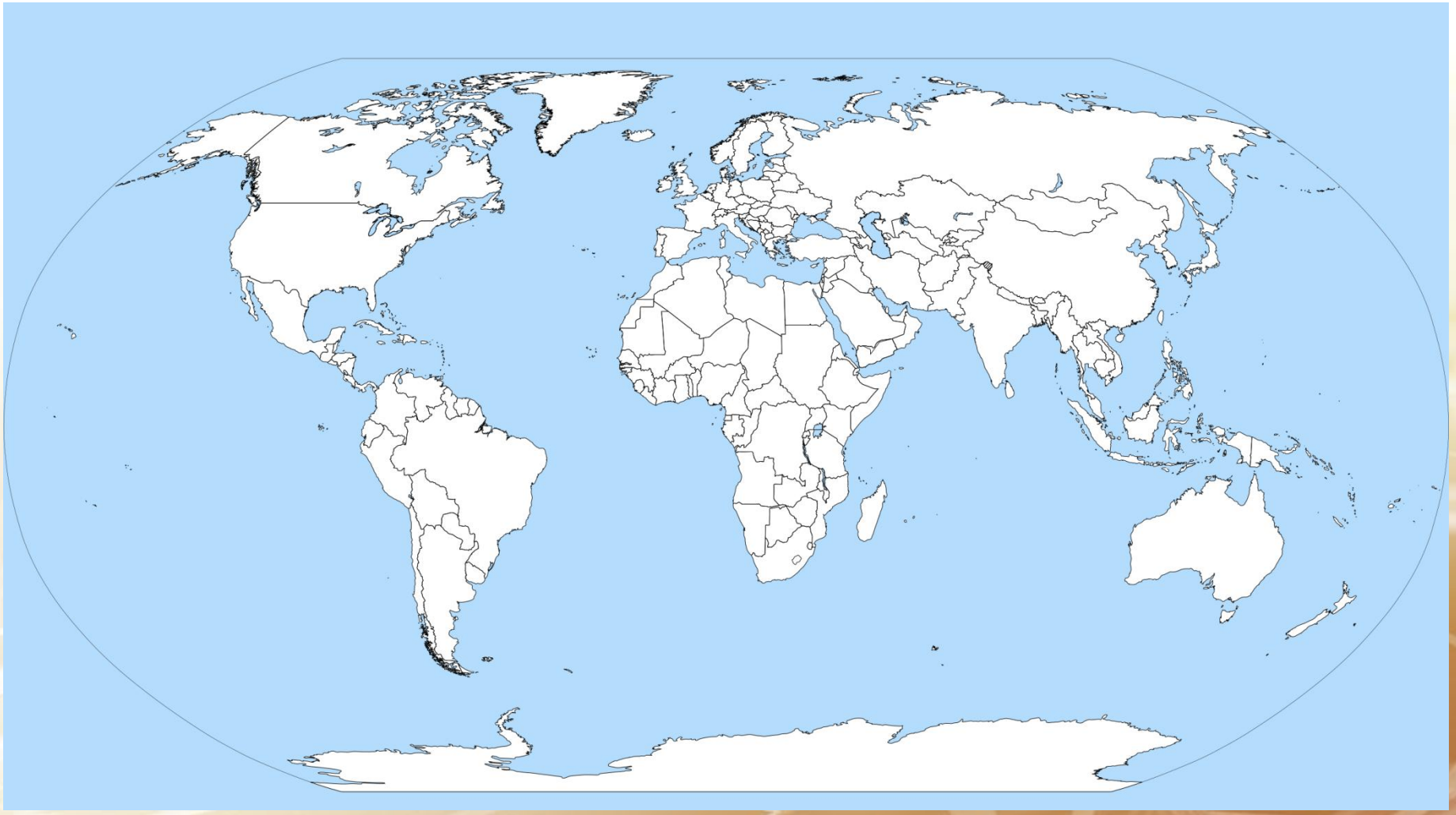
Conclusion

- The importance of the atomic power industry to the worlds energy security is becoming increasingly clear.
- Nuclear energy is the only large-scale, carbon-free electricity source that the world can widely expand to produce large amounts of electricity.
- Apart from this the other uses like nuclear research, Industrial appliances, health appliances, tools for common purposes which are discussed under above minerals uses heads , itself clears that increasing demand of atomic minerals accelerate the rate of the exploration and production of the atomic minerals and atomic energy in 21st century.

Questions for Exams and Assignments

- **Q1. What is Atomic Minerals? Discuss the distribution and production of major atomic minerals in the world?**
- **Q2. Explain the changes in production pattern of major atomic mineral resources in 21st century.**
- **Q3. Describe the characteristics, distribution and production of Uranium in the world?**
- **Q4.Examine the need of atomic energy based on atomic minerals in present energy crises scenario in the India/ World?**

Q5. Identify and mark the location of minning areas of different atomic minerals on the given World Map.



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