

Economic Geography for General Studies UPSC Civil Services Exam by Pmfias.com

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Economic Geography Part I

Distribution of key natural resources across India and the World

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Economic Geography

- Economic geography is the study of patterns of humans' economic activities ranging from production to consumption of various goods and services across the world.
- By 'human economic activities' we mean, production, location, distribution, consumption, exchange of resources, spatial organization of economic activities, etc.
- Different subject matters of economic geography include the distribution of mineral resources, location of industries, economies of agglomeration (economies of urbanization), transportation, international trade, the relationship between the environment and the economy, etc.

Importance of studying economic geography:

- It allows us to understand an area's economy and its economic relationship with other areas around the world.
- It helps us understand the reasons and methods of development of a region or lack of development thereof.
- It helps us find solutions to economic developmental challenges.

GS1 Syllabus:

1. **Distribution of key natural resources across the world (including South Asia and the Indian sub-continent); {Economic Geography Part I}**
2. **factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India). {Economic Geography Part II}**

GS3 Syllabus:

1. **Major crops cropping patterns in various parts of the country, different types of irrigation and irrigation systems storage. {Indian Agriculture}**
2. **Infrastructure: Energy, Ports, Roads, Airports, Railways etc. {Will be covered as a separate topic}**

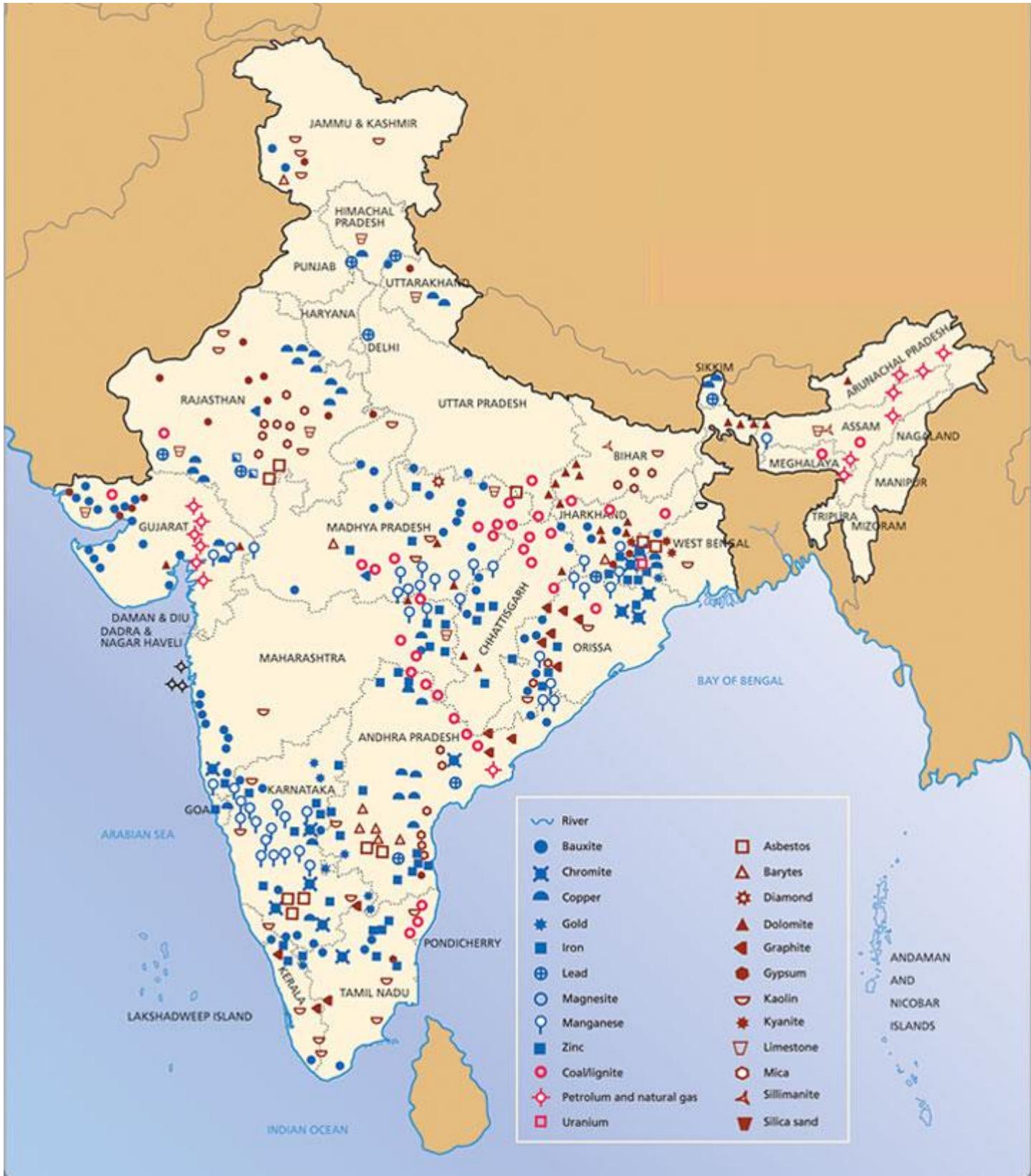
Natural Resources Classification	
Biotic	Abiotic
Renewable (Non-conventional): biomass, solar energy, wind energy, etc.	Non-renewable (Conventional): coal, oil, iron, etc.
Metallic: Iron, copper, tin, zinc, uranium (heavy metal), etc.	Non-metallic: graphite, diamond, mica, limestone, etc.

Renewable and Non-renewable energy resources will be covered as a part of General Science and Science and Technology.

1. Iron

- Based on the amount of ore and iron content, iron ore is classified into various types.

1.2 Types of Iron Ore



- Magnetite (Fe_3O_4) and Haematite (Fe_2O_3) are fine quality ores.
- Limonite, siderite, etc. are inferior ores that have their own unique characteristics.

Magnetite (Fe_3O_4)

- Magnetite has excellent **magnetic qualities**, hence the name.

- It is black in colour and has **very high content of Iron – upto 72 per cent (best quality iron ore)**.
- Magnetite has higher iron content than hematite (60-70 per cent); therefore, its **quality is higher**.
- However, unlike haematite ore, magnetite ore is **not found in high grades**.
- That is, while hematite ore generally contains large concentrations of hematite, magnetite ore generally holds low concentrations of magnetite.
- Hence the ore needs to be **beneficiated** (treat to improve its properties) for magnetite recovery.
- End products (e.g. steel) made from magnetite ore are typically of **higher quality** than those made from hematite ore. That's because **magnetite has fewer impurities than hematite**.
- Magnetite with less iron content (25% to 30%) is known as **Taconite**.
- A naturally magnetized content of magnetite is called **lodestone**.
- Distribution of magnetite ore in India: Dharwad and Cuddapah systems – **Karnataka (73%), Andhra Pradesh (14%), Tamil Nadu (5%), Rajasthan (5%)**, etc.

Haematite (Fe_2O_3)

- Reddish ore with naturally high iron content – **60 to 70 per cent**.
- Because of its high iron content, hematite ore can be used in steel production **without beneficiation**.
- Hematite is the most abundantly available ore in India.
- Distribution: **Odisha, Jharkhand, Chhattisgarh, Andhra Pradesh, Karnataka, Maharashtra and Goa**.

Limonite

- Limonite is inferior iron ore that is yellowish in colour with **40 to 60 per cent iron content**.

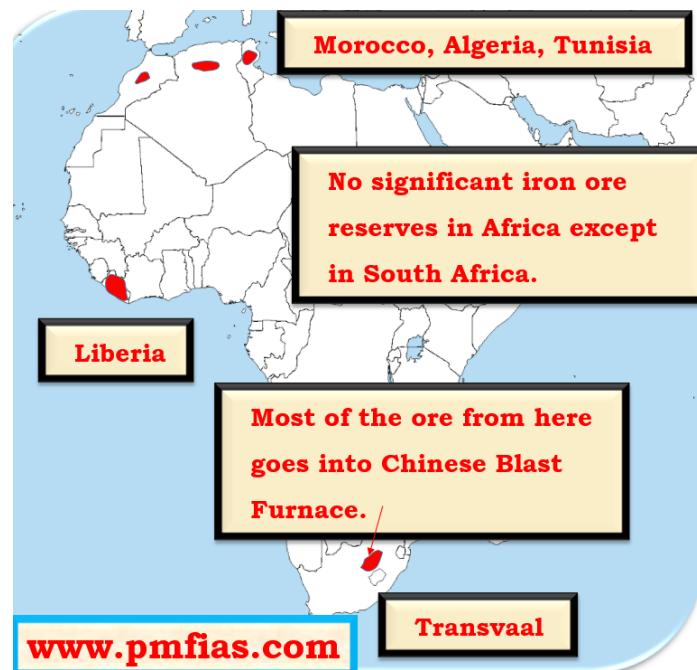
- Limonite mines are **open cast mines**; hence mining is **easy and cheap**.
- Distribution: **Damuda series in Raniganj coal field**, Garhwal in Uttarakhand, Mirzapur in Uttar Pradesh and Kangra valley of Himachal Pradesh.

Siderite (FeCO_3)

- It is **iron carbonate ore** of inferior quality with **less than 40 per cent iron content**.
- It contains many impurities and hence mining, in many places, is economically unviable.
- However, one good quality of the ore is that it doesn't contain sulphur or phosphorus.
- And also, it is **self-fluxing** due to the presence of lime.

1.3 Iron Ore Distribution Across the World

Iron ore in Africa: Transvaal, Liberia



Iron Ore in China: Manchuria, Sinkiang, Si-kiang, Shandog Peninsula



Japan is one of the biggest importers of Iron ore. It has no iron reserves but has a flourishing iron and steel industry.

Low grade ore all across China. So China depends on imported ore from Australia, Brazil, and Russia and produces steel domestically and it leads in steel exports. India's export to China declined due to court orders and India had to import iron ore from other countries

Iron Ore in Europe: Ruhr, South Whales, Krivoy Rog, Bilbao, Lorraine

Flourishing automobile industry. Volkswagen, Benz, Audi, BMW and many more automobile companies have their headquarters here

South Whales and Middleland

Dannemora

Russia has lot of reasons to capture eastern Ukraine. Krivoy Rog Iron reserves and Donbass coal mines Are present here

Lorraine

Rhur

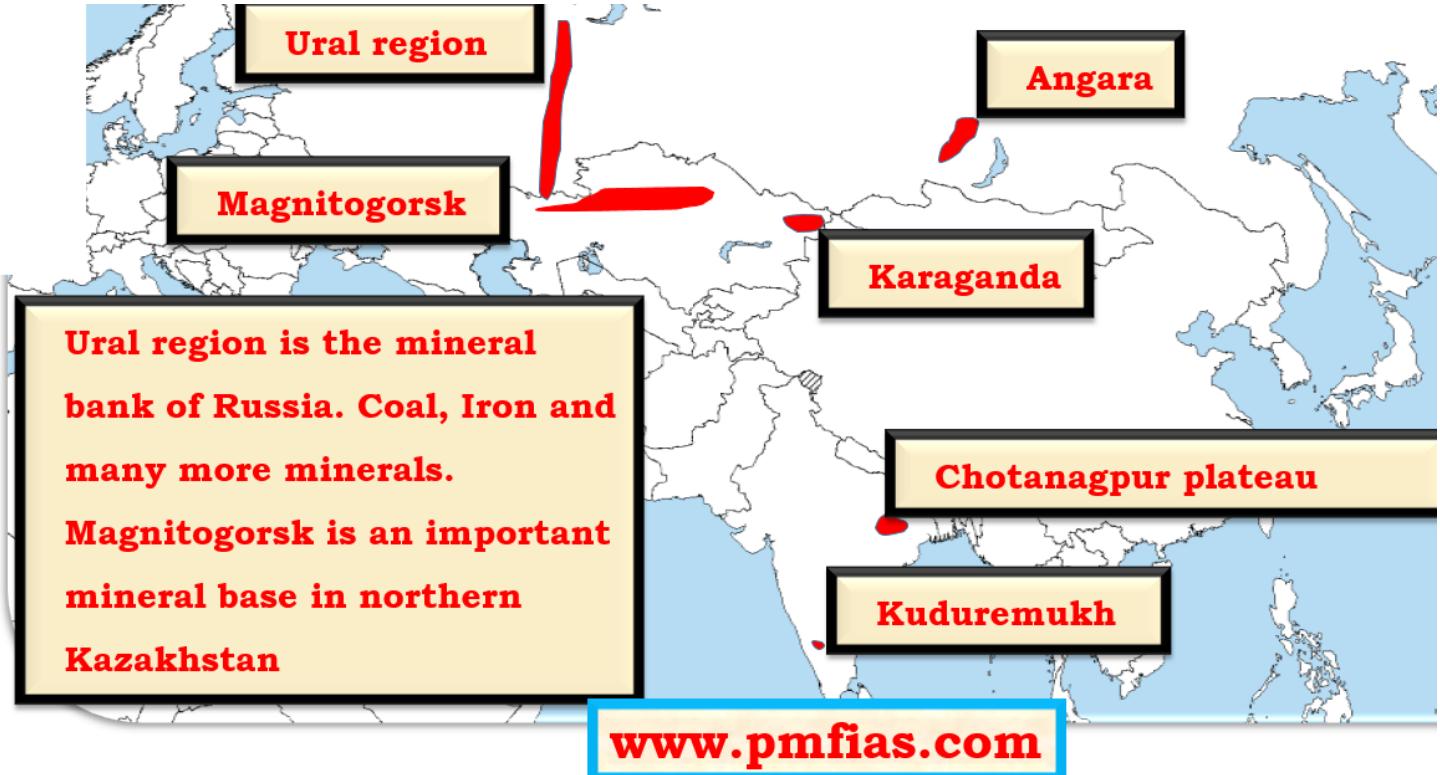
Bilbao

Krivoy Rog

Pyrenees

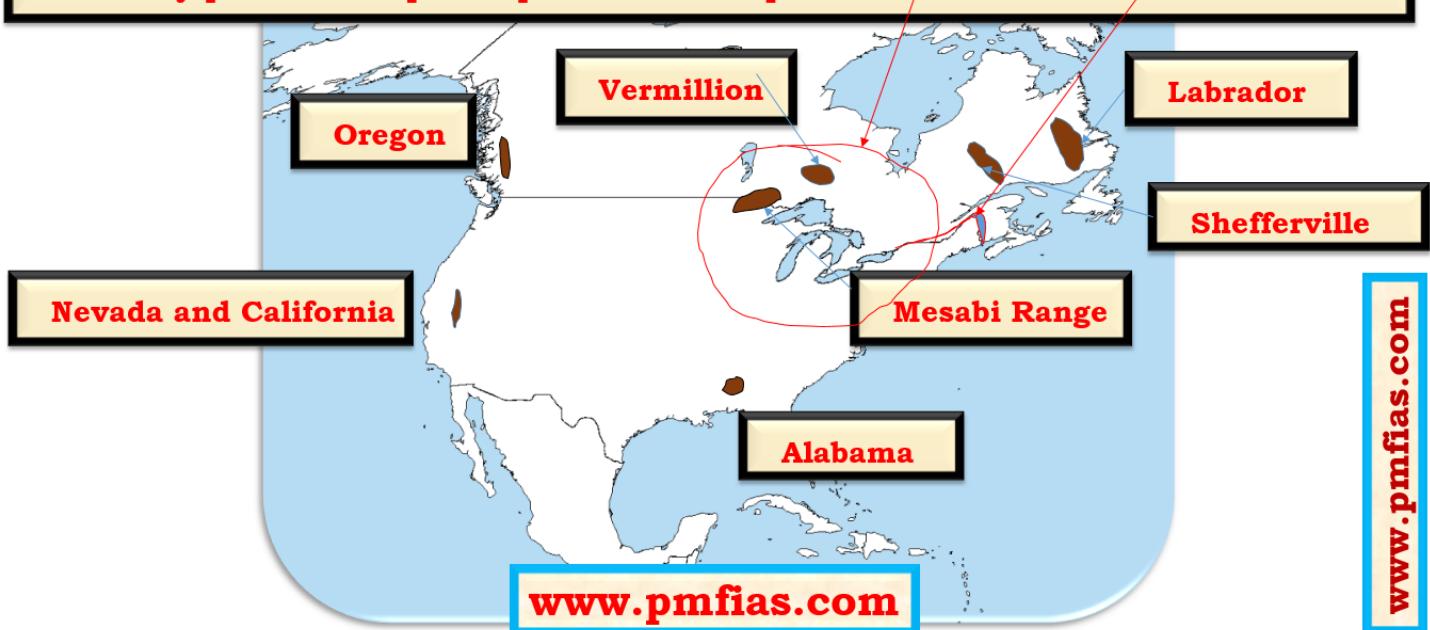
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Iron ore in Russia, Kazakhstan: Ural region, Magnitogorsk



Iron Ore in North America: Great Lakes (Mesabi Region), Labrador

Great Lakes region has lot of industries around it. Most of the iron and steel is consumed domestically by automobile industry. Great Lakes and St. Lawrence waterway provide cheap transportation for exports



Iron Ore in South America: Carajas, Itabira, Minas Gerais

Cerro Bolivar [Guiana Highlands]

Most of the ore from Brazil is exported to China and Japan

Algarrobo

Carajas mines → largest iron ore mine in the world

Largest deposits of high grade iron ore

Itabira, Minas Gerais [Brazilian highlands]

- Brazil has one of the largest reserves of high grade hematite ore.

Iron Ore in Australia: Pilbara Region, Koolyanobbing, Iron Duke, Iron Knob

Pilbara region: Most of the ore from here goes into Chinese and Japanese Blast Furnaces.

One of the most productive mineral bases of Australia.

Pilbara region

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Koolyanobbing → Greatly overshadowed by Pilbara Regions

Iron Knob and Iron Duke → The Birthplace of Australian Steel Industry.

Largest iron ore producers

Country	Iron Ore Production
1. Australia	900 Million tonnes – most of the ore is exported to China.
2. Brazil	490 Million tonnes – most of the ore is exported to China.
3. China	340 Million tonnes – very high demand for iron in the region.
4. India	210 Million tonnes – Post SC ban on mining in Goa, Odisha and Karnataka in 2010, India's import of iron ore grew substantially.

Largest iron ore reserves

Largest iron ore reserves		• Top Iron ore producers in the world (All the data is in million tonnes.)			
World Total	840 billion tons	Country	2017	2018	
1. Australia	240 billion tons	China	1229	~1300 – very high demand for iron in the region.	
2. Brazil	170 billion tons	Australia	885	900 – most of the ore is exported to China.	
3. Russia	140 billion tons	Brazil	436	490 – most of the ore is exported to China.	
4. China	69 billion tons	India	201	210 (~4.7%) – Post SC ban on mining in Goa, Odisha and Karnataka in 2010, India's import of iron ore grew substantially.	
5. India	32 billion tons	Russia	95		

- India had produced 209.00 million tonnes of iron ore in 2010, before the clampdown on illegal mining in the country by the Supreme Court.

1.4 Iron Ore Distribution in India

- In India, the main deposits of iron ore are located in the states of **Odisha, Jharkhand, Chhattisgarh, Karnataka and Goa**, with **Odisha contributing ~50% of India's total production**.

- Hematite** and **magnetite** are the two most important iron ores in India.
- Of these, hematite is considered to be the most important iron ore **because of its high grade quality**, which is consumed by a large number of steel & iron industries in the country.
- Most of the larger iron ore belts already explored for high-grade ores have been exploited through the last six decades.
- The country has huge resources/reserves of low-grade iron ore but mining efforts to tap low-grade ores have not been adequate.

Ore	Reserve resource	Remaining resource	Total resource (total reserves)
Hematite	5 billion tons	17 billion tons	22.5 billion tons
Magnetite	52699 million tons (0.2%)	10.7 billion tons	10.8 billion tons

- Reserve Resource (total recoverable reserves):** can be commercially exploited at present.
- Remaining resource (total unrecoverable reserves):** cannot be commercially exploited at present due to low grade ore or lack of adequate technology or environmental concerns, etc.

Haematite reserves	Magnetite reserves
<p>1. Odisha 33%</p> <p>2. Jharkhand 26%</p> <p>3. Chhattisgarh 18%</p> <p>Rest in Andhra Pradesh, Karnataka, Goa, Assam, Bihar, Maharashtra, MP, etc.</p>	<p>1. Karnataka 73%</p> <p>2. Andhra Pradesh 14%</p> <p>3. Rajasthan 5%</p> <p>4. TN 5%</p>

Hematite reserves

- Almost the entire present-day production of iron & its products comes from **hematite reserves**.
- Around 96% of hematite resources are confined in Orissa, Jharkhand, Chhattisgarh, Karnataka and Goa.
- In Jharkhand & Orissa and in adjoining areas in eastern India, hematite occurs associated with limonite.

- In **Bellary-Hospet region** of Karnataka, hematite ore occurs with minor amounts of magnetite.
- Important hematite accumulations are in **Singhbhum district (Jharkhand), Keonjhar (Orissa), Bellary (Karnataka), Bastar district (Chhattisgarh)** and Goa.

Magnetite reserves

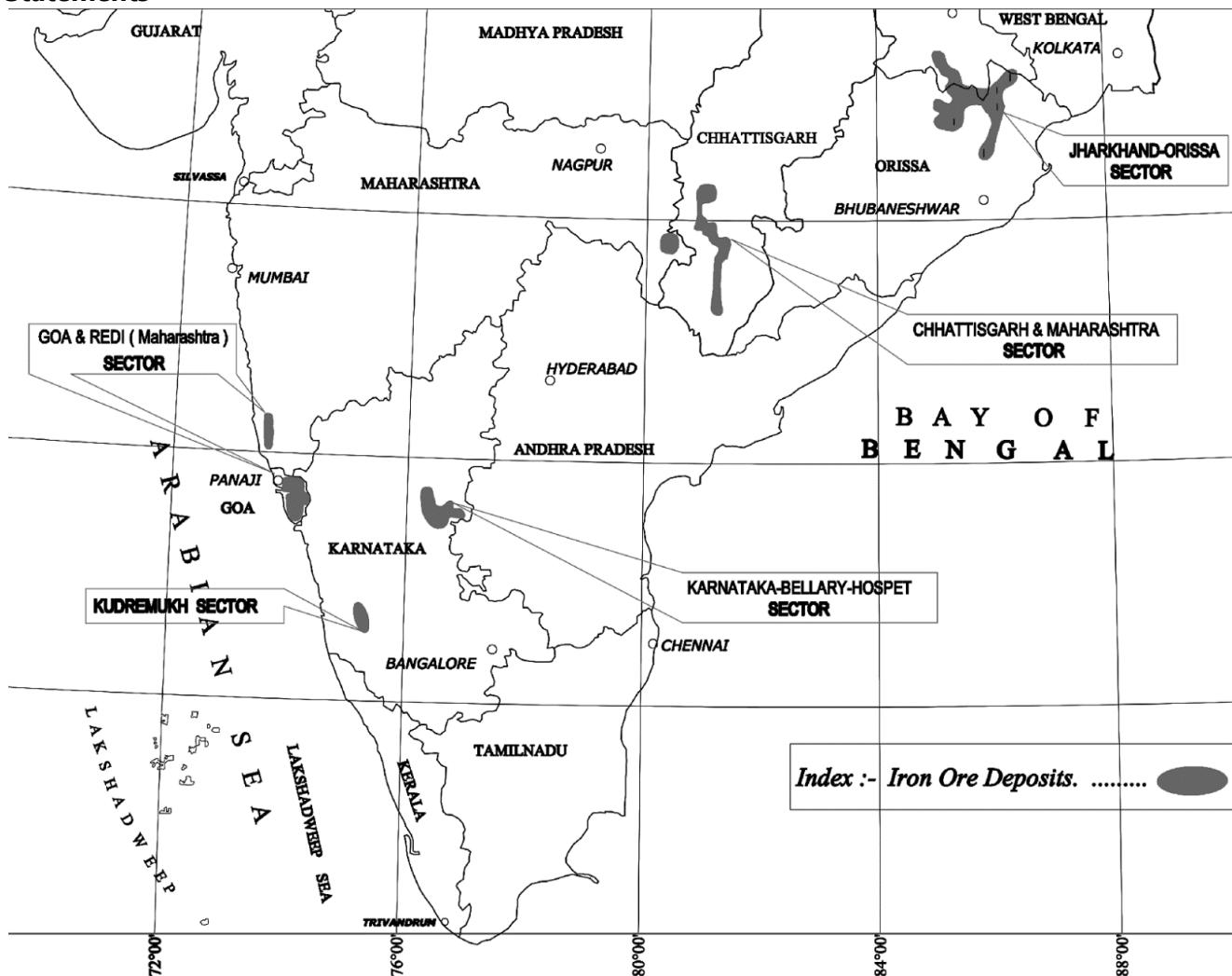
- Magnetite reserves are not being exploited as these are mostly in **eco-fragile areas of the Western Ghats**.
- Magnetite would remain locked up until environmentally sustainable mining technologies are invented.
- Magnetite ore deposits are mainly confined to the **Chikmagalur district (Kudremukh (Bababudan hills)) in Karnataka** and **Salem and North Arcot** districts in Tamil Nadu.

- Karnataka has more than half of the reserves of magnetite ore in India.
- Jharkhand has the highest reserves of haematite ore in India.

Which of the above are true?

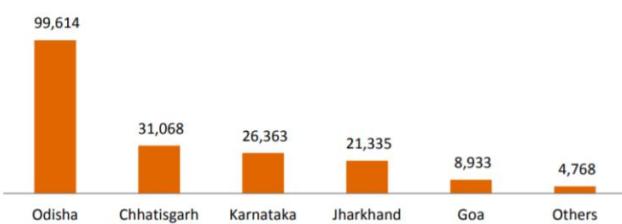
- Both
- 1 only
- 2 only
- None

Q1. Statements



Iron Ore Production in India

Chart 6: Production of iron ore in FY17 (in '000 tonnes)



- The total iron ore production in India in FY17 stood at ~192mn tonnes.
- Indian exports of iron ore stood at 24.1 mn tonnes and imports were 8.7 mn tonnes in FY18.
- Sale of iron ore from Karnataka mines had fallen sharply with domestic steel producers buying the ore from Chhattisgarh and Odisha due to better quality at cheaper price.

Odisha	<ul style="list-style-type: none"> The ores are rich in haematites. India's richest haematite deposits are located in Barabil-Koira valley. Others: Sundargarh, Mayurbhanj, Cuttack, Sambalpur, Keonjhar and Koraput.
Chhattisgarh	<ul style="list-style-type: none"> Bailadila mine is the largest mechanised mine in Asia (only beneficiation is done here). A pipeline from the Bailadila to Vizag plant transports the ore slurry (semi-liquid mixture). Smelting is done in Vizag (Vishakhapatnam) iron and steel factory. Bailadila's high grade ore is exported through Vishakhapatnam to Japan (there are no iron ore reserves) and other countries.
Jharkhand	<ul style="list-style-type: none"> First mine in Singhbhum district in 1904. Iron ore of here is of highest quality and will last for hundreds of years. Noamandi mines in Singhbhum are the richest. Magnetite ores occur near Daltanganj in Palamu district.
Karnataka	<ul style="list-style-type: none"> High grade ore deposits are those of Kemmangundi in Bababudan hills of Chikmagalur district (magnetite) and Sandur and Hospet in Bellary district (hematite). Most of the ores are high grade haematite and magnetite.

Iron ore in other states

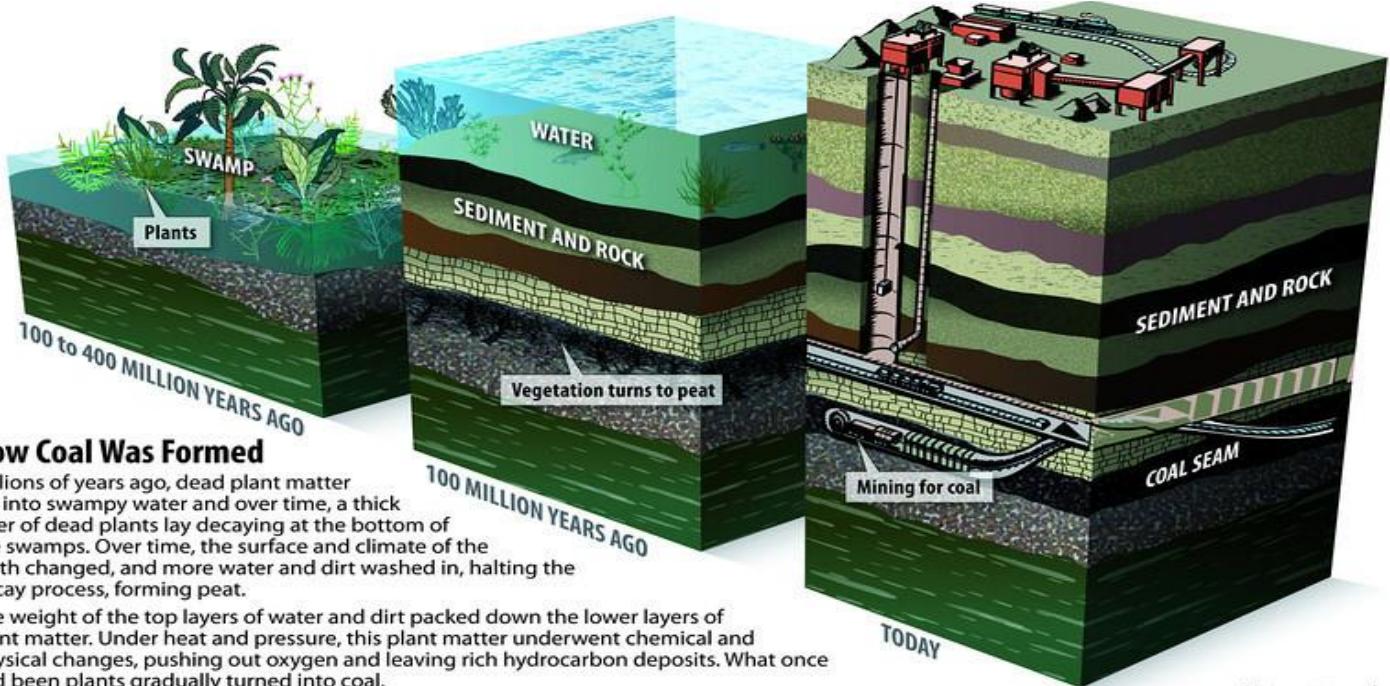
- Andhra Pradesh:** Rayalaseema region.
- Maharashtra (0.88%):** Chandrapur, Ratnagiri and Sindhudurg.
- Tamilnadu:** Salem, Tiruchirapalli, Coimbatore, Madurai etc.

2. Coal

- Coal is also called **black gold**. It is found in sedimentary strata (layers).
- Coal contains **carbon, volatile matter, moisture** and **ash** (in some cases **Sulphur** and **phosphorous**).

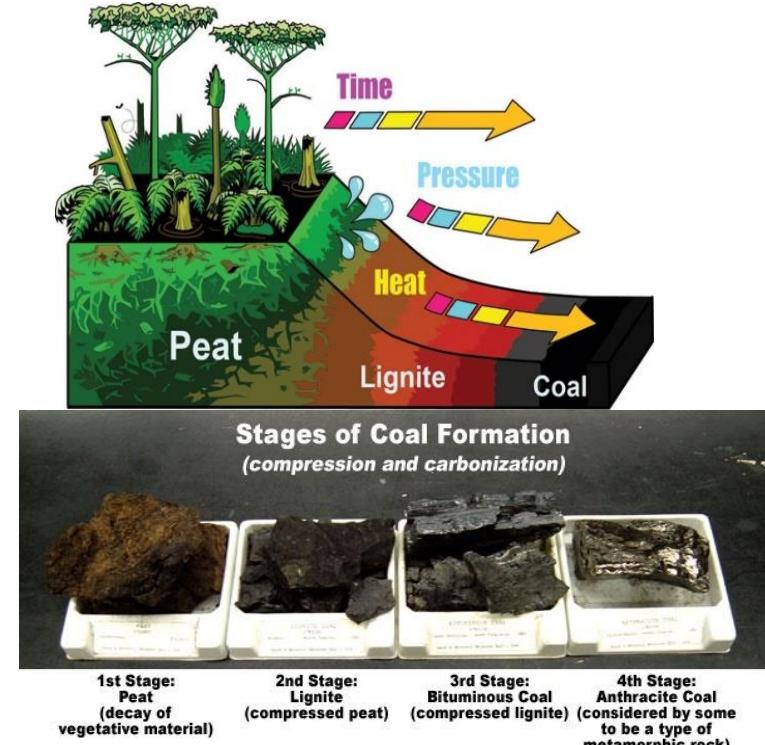
2.1 Formation of Coal

- Most of the world's coal was formed in **Carboniferous age (350 million years ago – Best quality coal)**.



- The name Carboniferous refers to coal-bearing strata.
- Coal formed millions of years ago when the earth was covered with huge swampy (marshy) forests.
- As the plants grew, some died and fell into the swamp waters.
- New plants grew up to take their places and when these died still more grew.
- In time, there was thick layer of dead plants rotting in the swamp.
- The surface of the earth changed, and water and dirt washed in, **stopping the decaying process**.
- More plants grew up, but they too died and fell, forming separate layers.
- After millions of years many layers had formed, one on top of the other.
- The weight of the top layers and the water and dirt packed down the lower layers of plant matter.
- Heat and pressure produced chemical and physical changes in the plant layers which **forced out oxygen and left rich carbon deposits**. In time, material that had been plants became coal.

- sub-bituminous coal is altered to bituminous coal, and**
- bituminous coal is altered to anthracite (oldest, best quality coal).**



2.2 Classification of coal

- Coals are classified into **peat, lignite, bituminous coal, and anthracite**.
- These classifications are based on the **amount of carbon, oxygen, and hydrogen present in the coal**.
- Coal's other constituents include **hydrogen, oxygen, nitrogen, ash, and sulphur**.
- Some of the undesirable chemical constituents include **chlorine and sodium**.

Peat

- Contains **less than 40 to 55 per cent carbon (has more impurities)**.
- Contains sufficient volatile matter and **lots of moisture** (gives out a lot of smoke when burnt → **pollution**).
- Left to itself, it burns like **wood**, gives less heat, **emits more smoke** and leaves a **lot of ash**.

Stages of coal formation

- In the process of transformation (coalification),
 - Buried plants turn into peat,**
 - Peat is altered to lignite,**
 - lignite is altered to sub-bituminous,**



Lignite (brown coal)

- Contains **40 to 55 per cent carbon**.
- Moisture content is high (over 35 per cent).
- It undergoes **spontaneous combustion** (this is undesirable because it creates **fire accidents in mines**).
- Distribution: Rajasthan, Lakhimpur (Assam), and Tamil Nadu.



Bituminous Coal (black coal)

- Bituminous Coal is soft, dense, compact coal with **40 to 80 per cent carbon**.
- Bituminous Coal is the **most widely available and used coal**.
- It derives its name after a liquid called **bitumen**.
- Moisture and volatile content are low (15 to 40 per cent).

Coking Coal vs. Non-Coking Coal (Thermal Coal)

- **It does not have traces of original vegetable material.**
- Calorific value is **very high** due to high proportion of carbon and low moisture.
- It is used in the production of **coke and gas**.
- Distribution: Jharkhand, Odisha, West Bengal, Chhattisgarh and Madhya Pradesh.



Anthracite Coal (Semi-metallic lustre)

- **Anthracite coal is the best quality**, hard coal with **80 to 95 per cent carbon**.
- It has very little moisture and volatile matter.
- It **ignites slowly** and hence there is less loss of heat (highly efficient).
- It burns with a short **blue flame** (**Complete combustion → Flame is blue → very few pollutants**).
- In India, it is found only in **Jammu and Kashmir** and that too in small quantity.



Coking Coal or Metallurgical Coal	Thermal Coal or Non-Coking Coal or Steaming coal
<ul style="list-style-type: none">• High carbon content, less moisture, less sulphur, less ash.	<ul style="list-style-type: none">• Sulphur content is high and hence cannot be used in iron and steel industry. (Sulphur reacts with iron to form iron sulphide (FeS). Iron sulphide is brittle (hard but easily breakable) and makes the whole metal and its alloys brittle.)
<ul style="list-style-type: none">• Used to create coke.• Coke is produced by heating bituminous coal without air to extremely high temperatures.• Coking → flushing out impurities and improving the concentration of carbon.• Coking coal is an essential ingredient in steel	<ul style="list-style-type: none">• Creating coke using this coal is not economical.• Moreover, traces of sulphur will remain even after coking.• Thermal coal is used to generate power.

<p>production.</p> <ul style="list-style-type: none"> Major producers: Australia, Canada, United States. Major exporters: Australia, Canada, United States. China imports huge amount of coking coal from Australia. India also imports coking coal. 	<ul style="list-style-type: none"> Major producers: China, Australia, USA, Russia. Major exporters: Australia, South Africa.
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2.3 Distribution of Coal in India

- Coal reserves are six times greater than oil and petroleum reserves.
- In India, during the year 2016-17, about 82% coal and lignite got despatched to the Power Sector.

Gondwana Coal (formed 250 million years ago)

- Around 98 per cent of India's coal reserves and 99% of total coal production are from Gondwana fields.
- The carbon content in Gondwana coal (**250 million years old**) is less compared to the Carboniferous coal (**350 million years old – almost absent in India**) because of its much younger age.
- The volatile compounds and ash (~ 30%) don't allow carbon percentage to rise above **60%**. (It

requires a few million years more for the quality has to get better).

- Gondwana coal is **free from moisture**, but it contains **Sulphur** and **phosphorus**.
- Coking as well as non-coking coal and bituminous coal are obtained from Gondwana coal fields.
- Anthracite** is **generally not found** in the Gondwana coal fields.
- The **Damuda series (i.e. Lower Gondwana)** possesses the best worked coalfields accounting for 80 per cent of the total coal production in India.
- Gondwana coal occur in the valleys of certain rivers viz., the **Damodar (Jharkhand-West Bengal)**; the **Mahanadi (Chhattisgarh-Odisha)**; the **Son (Madhya Pradesh Jharkhand)**; the **Godavari and the Wardha (Maharashtra-Andhra Pradesh)**.

Jharkhand	<ul style="list-style-type: none"> Most of the coal fields in the state of Jharkhand are located in a narrow belt running in the east-west direction almost along 24 degrees north latitude. The main coal fields at Bokaro, Jharia, Deltanganj, Dhanbad, Auranga (Palamu), Giridih, Karanpura, Ramgarh, Hutar, Devgarh and Rajmahal coalfields. Jharia coalfield is one of the oldest and richest coal fields of India. It stores the best of metallurgical coal (bituminous coking coal) in the country. Bokaro coalfield lies in Hazaribagh district. It is a long but narrow strip in the catchment area of the Bokaro river. Girdih (Karharbari) coalfield gives out of the finest coking coal in India. <p>Coking Coal Production by State</p> <ol style="list-style-type: none"> 1) Jharkhand (More than 90% of India's Coking coal comes from Jharkhand) West Bengal Madhya Pradesh
Odisha	<ul style="list-style-type: none"> Most of the coal deposits of the state are found in Sambalpur, Dhenkanal, and Sundargarh districts. Talchar coalfield of Odisha stretch over Dhenkanal and Sambalpur districts covers an area of about 500 sq km.

	<ul style="list-style-type: none"> Talcher field ranks second in reserves after Raniganj. Coal from this field is most suitable for steam and gas production. Most of the coal is utilised in thermal power and fertilizer plants at Talcher. Other coalfields of the state include Rampur-Himgir and Ib river.
Chhattisgarh	<ul style="list-style-type: none"> Korba coalfield lies in the valley of river Hasdo (tributary of Mahanadi). Other coalfields of the state include Hasdo-Arand, Chirmiri, Jhimli, Johilla, Birampur, Lakhanpur, Sonhat, Tatapani-Ramkota, etc.
West Bengal	<ul style="list-style-type: none"> First coal mine of India was opened in 1774 at Raniganj (largest coalfield of West Bengal). Raniganj coalfield is the most important coal reserve and mining coalfield of West Bengal. It stretches across Bardhaman, Birbhum, Bankura and Purulia districts to the northwest of Kolkata. Small part of this field is in Jharkhand state. It is known for good quality coal with about 50 to 65 per cent carbon content. Darjeeling (Dalingkot coalfield) and Jalpaiguri are the chief producing districts.
Madhya Pradesh	<ul style="list-style-type: none"> The main coal deposits of the state lie in Singrauli, Muhipani, Satpura, Pench Kanhan and Sohagpur. Singrauli (Waidhian) is the largest coalfield of MP. It supplies coal to the thermal power plants at Singrauli and Obra. Jhingurda, Panipahari, Khadia, Purewa and Turra are important coal seams Jhingurda with a total thickness of 131 m is the richest coal seam of the country. Pench-Kanhan-Tawa in Godavari seam in Kanhan field contains coking coal
Telangana & Andhra Pradesh	<ul style="list-style-type: none"> Godavari valley holds the coal of Telangana and Singareni coalfield is the main mine. Most of the coal reserves are in the Godavari valley: Adilabad, Karimnagar, Warangal, Khammam, East Godavari (AP), and West Godavari (AP). Almost the entire coal is of non-coking variety. These are the southernmost coalfields of India and a source of coal supply to most of south India.

Tertiary Coal (formed 60 – 15 million years ago)

- Tertiary coal generally has **low carbon** and **high percentage of moisture** and **Sulphur**.
- Lignite deposits** occur in the tertiary sediments in the extra-peninsular region particularly in **Tamil Nadu, Kerala, Gujarat & Rajasthan** and also in **Jammu & Kashmir**.
- The total known geological reserves of lignite as of 2017 is 44.7 billion tonnes, of which 80% reserves are located in **Tamil Nadu**.
- Peat deposits occur in **Nilgiri hills** and **Kashmir valley** (in the alluvium of the Jhelum).

Maharashtra	<ul style="list-style-type: none"> Kamptee coalfields (in Nagpur district) and Wardha valley (stretched over Nagpur and Yavatmal districts) carry most of the coal deposits in the state. The coal deposits of Maharashtra mainly belong to the Tertiary period.
Tamil Nadu	<ul style="list-style-type: none"> The coal deposits of Tamil Nadu (80% lignite coal reserves) are found in Neyveli in the South Arcot district.
Rajasthan	<ul style="list-style-type: none"> Palana and Khari mines of Bikaner district in Rajasthan carry Lignite deposits (inferior quality of coal). The coal produced is mainly used in the thermal power plants and railways.
Gujarat	<ul style="list-style-type: none"> The coal found in Gujarat is of poor quality and contains only about 35 per cent of carbon. The moisture content in this coal is quite high.
Jammu & Kashmir	<ul style="list-style-type: none"> Coal in the state is of inferior quality and is found at Shaliganga, Handwara, Baramulla, Riasi, and Udhampur districts along with the Karewas of Badgam and Srinagar.
Assam	<ul style="list-style-type: none"> Makum coalfield in Sibsagar district is the most developed field. Assam coals contain very low ash and high coking qualities, but the sulphur content is

	<p>high, as a result of which this coal is not suitable for metallurgical purposes.</p> <ul style="list-style-type: none"> The coal is best suited for hydrogenation process and is used for making liquid fuels. Upper Assam Coal belt extends eastwards as Namchick-Namrup coalfield (Arunachal Pradesh).
Meghalaya	<ul style="list-style-type: none"> Garo, Khasi and Jaintia hills. Darrangiri field is in Garo hills. Cherrapunji and Langrin coalfields are in Khasi and Jaintia hills.

State-wise coal reserves and coal production in India

- India has a total of **319 billion tons** of coal reserves of which **148.8 billion tons are proven reserves**.

State-wise coal reserves in India			State-wise raw coal production in India		
State	Reserves (billion tons)		State	2016-17	2017-18
1. Jharkhand	80.71	26.8 %	1. Odisha	139	143
2. Odisha	75.07	24.9 %	2. Chhattisgarh	128	132
3. Chhattisgarh	52.53	17.4 %	3. Jharkhand	118	112
4. West Bengal	31.31	10.4 %	4. Madhya Pradesh	85	91
5. Madhya Pradesh	25.67	8.5 %	5. Maharashtra	40	41
6. Telangana & AP	22.48	7.5 %	6. West Bengal	25	26
7. Maharashtra	10.98	3.6 %	7. Uttar Pradesh	16	18

[Source](#)

The demand of coal, production, supply and import of coal in India

Data in Million Tons (MT)				India's coal imports country-wise		
Year	2015-16	2016-17	2017-18	Country	FY 2016-17	FY 2017-18
Total domestic Production	639.23	657.87	676.48	1. Indonesia	117	97
Total domestic Supply	632.44	644.56	691.42	2. Australia	46	46
Total Import (MT)	203.95	190.95	208.27	3. South Africa	38	35

- Coal India Ltd (CIL) has planned to increase coking coal output from **34.12 MT** to 52.95 MT by 2019-20.

In Million Tons (MT)	FY 2018-19	Non-coking coal imports
Total coal imports	220	1. Australia (~ 70%)
Non-coking coal imports	164	2. Canada (~ 10%)
Coking coal imports	52	3. USA (~ 7%), Mozambique (~ 5%)

Why does India import coal although it has enough reserves?

Inability to exploit reserves

- Unavailability of technology to mine coal from deep underground coal mines (40% of total coal reserves are located at a deeper depth which cannot be extracted using opencast mining).

- Significant portions of Indian coal reserves are in Maoist affected regions and densely populated areas.

Short supply of coking coal (metallurgical coal)

- Coke is an important ingredient in the manufacture of iron (coke acts as fuel in a blast furnace).

- India has very few coking coal sources and hence it has to import it from **Australia, Canada, South Africa, Indonesia**, etc.

Environmental concerns

- India's coal has high ash content and low calorific value. Hence burning it causes a lot of pollution.

Lack of dedicated freight corridors (railway lines for goods trains)

- The distribution of coal is uneven.
- The movement of freight in India is slow (goods trains have to make way for passenger trains) as Indian railways doesn't have dedicated freight corridors.
- Hence it is sometimes convenient and/or less expensive to import coal.

Coal India is not able to meet the demand of captive power plants

- Aluminium smelters, cement makers and other industrial users that power their factories using

Major Coalfields in India



1. Singrauli
2. Karanpura Bokaro

- Previously, due to shortage of coal and pollution concerns, many Indian power plants had been designed to run on superior quality imported coal.
- Clean coal technology used to clean coal to reduce emissions is expensive and complex to setup. their own coal powered power plants (captive power plants).
- Given these consumers have to run their captive power plants in order to produce their goods, they have no option but to turn to imports when Coal India can't meet their needs.
- There is about 30 gigawatts (GW) of coal-fired generation capacity that is used by captive power plants.

Captive power plant: A captive power plant provides localised source of power to an energy user. These are typically industrial facilities or large offices.

3. Jharia
4. Raniganj
5. Ib & Talcher
6. Pench & Kanhan
7. Singareni – Godavari Valley
8. Lignite: TN, Gujarat And Rajasthan

Measures taken by the government to boost production

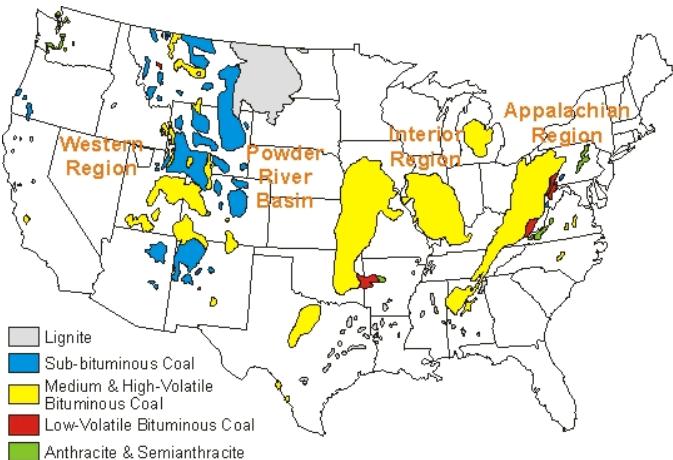
- Indian coal industry was plagued with low productivity, primitive technology, etc.
- Hence in 1975 public sector and private sector companies were liquidated to form **Coal India Limited**.
- Since 1975, all mining activities were undertaken only by Coal India Ltd. and its subsidiaries.
- The centralization of the coal industry resulted in lack of innovation and the sector soon became stagnant.
- In 2004, GOI decided to allocate coal blocks to private companies for captive mining (coal for personal use).

- But the procedure of allocation was embroiled in corruption (Coalgate scam: coal blocks were allocated without any competitive bidding during the period 2004–2009).
- GOI **opened up commercial coal mining** for the private sector in 2018 and approved the methodology for auction of coal mines / blocks for sale of coal.

2.4 Distribution of Coal across the World



USA	<ul style="list-style-type: none"> • Allegheny and Appalachian Mountains have enormous coal deposits. • Carboniferous coal of Great Lakes and Appalachians region helped USA become a leading industrialized nation. • However, most of the coal in the USA comes from western surface mines of Wyoming's Powder River Basin. • The North Antelope Rochelle Coal Mine located in the Powder River Basin of Wyoming is the world's biggest coal mine.
China	<ul style="list-style-type: none"> • China is the largest producer and consumer of coal in the world. • China's coal is of poor quality. It imports metallurgical grade coal from Australia. • There are intensifying environmental concerns (Photochemical smog) all over China due to coal burning.
Russia	<ul style="list-style-type: none"> • Ural region and the Donbass Basin are important mining regions. • Most of the Russia's coal in Siberian Region is untapped.
Europe	<ul style="list-style-type: none"> • Coal reserves in Ruhr and Rhineland region coupled with rich iron deposits have made Germany a leading industrial superpower of Europe. • England too benefited immensely from its coal reserves of South Whales, Yorkshire, Manchester, Liverpool etc. Industrial revolution began here mainly due to rich coal reserves.
Brazil	<ul style="list-style-type: none"> • Brazil is a leading coal producer in South America. • Most of the coal goes into power generation. Excess production is exported to China.
Australia	<ul style="list-style-type: none"> • Australia is a leading producer of coal. Most of its coal is exported to China, Japan etc. • Australia has rich coking coal deposits. India imports coking coal mainly from Australia.
Africa	<ul style="list-style-type: none"> • South Africa is the only region in Africa with significant amount of coal reserves.



Global Coal Reserves

- As of 2015, total proved recoverable reserves of coal were about **1.14 trillion tons**.
 - United States – 22%**
 - Russia – 16%**
 - Australia – 14%**
 - China – 13%**
 - India – 9%**

Top coal producers and consumers in the world

Top coal producers in the world (All data is in million tons)			Top coal consumers		
Country	2016	2017	Country	2017	
1. China	3411	3445	1. China	1890	51%
2. USA	700	775	2. India	424	11%
3. India (Bituminous + Lignite)	658 + 45	679 + 48	3. USA	332	9%
4. Australia (Bituminous & Brown coal)	503	492	4. Japan	102	3%
5. Indonesia (Anthracite & Bituminous)	456	461	5. Russia	92	3%
6. Russia	385	410			
7. South Africa (Anthracite & Bituminous)	251	252			
World Total (All data is in million tons)	7469	7632			

3. Petroleum and Mineral Oil

- Petroleum (Petric means rock; Oleum means oil) is obtained from **sedimentary rocks** of the earth.
- Constituents of Petroleum include **90 to 95 per cent hydrocarbons** and 5 – 10% organic compounds containing **oxygen, nitrogen, sulphur** and traces of organometallic compounds.

- Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.

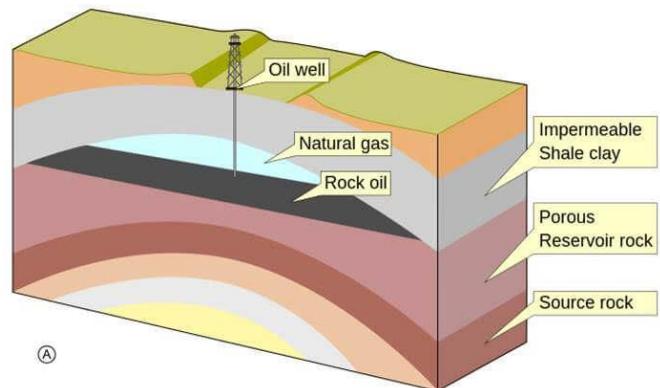
Conditions for Formation of Petroleum and Mineral Oil

- All sedimentary rocks do not contain oil.
- An oil reservoir must have three prerequisite conditions.
 - Porosity (tiny gaps in soil)** so as to accommodate sufficiently large amounts of oil;
 - Permeability** (allowing liquids or gases to pass through) to discharge oil and/or gas when well has been drilled;
 - Porous sandstone beds or fissured limestone containing oil should be capped below by impervious beds** (not allowing fluid to pass through).

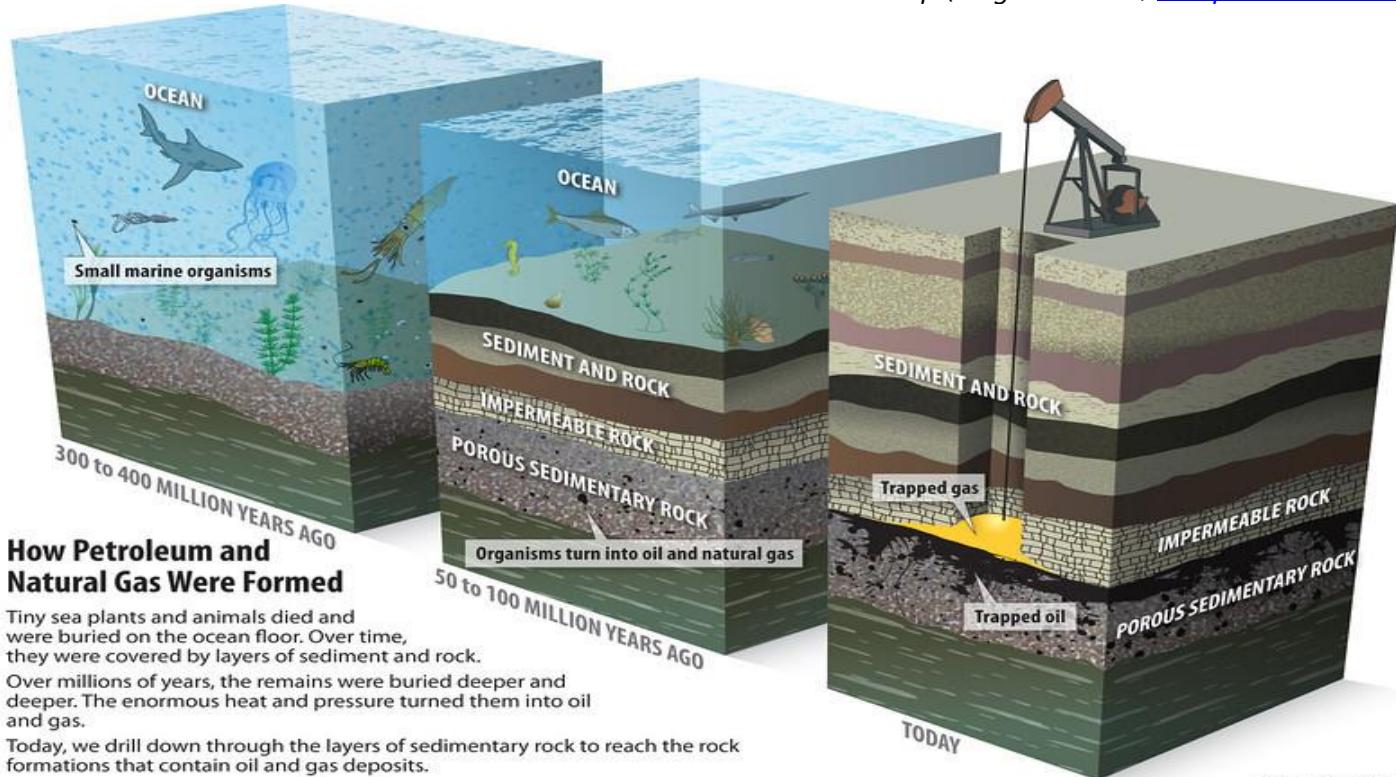
3.1 Formation of Petroleum and Mineral Oil

- Tiny sea plants and animals died and were buried on the ocean floor.
- Over time, they were covered by layers of sediment and rock.
- Over millions of years, the remains were buried deeper and deeper.
- The enormous heat and pressure turned them into oil and gas.

- Most of the oil gets collected in the **anticlines or fault traps**.
- Oil on a commercial scale is usually found in **crests of anticlines** (where the sedimentary rock strata are inclined and folded).
- Formation of exploitable reservoirs of hydrocarbons requires migration (from their source rocks) to **geological traps** comprising a **porous reservoir rocks** and **overlain by an impermeable horizon**.



Anticline trap (MagentaGreen, [Wikipedia Commons](#))



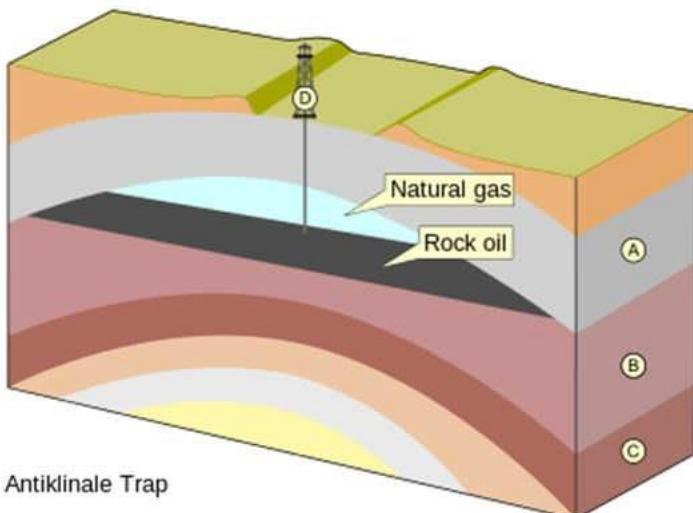
How Petroleum and Natural Gas Were Formed

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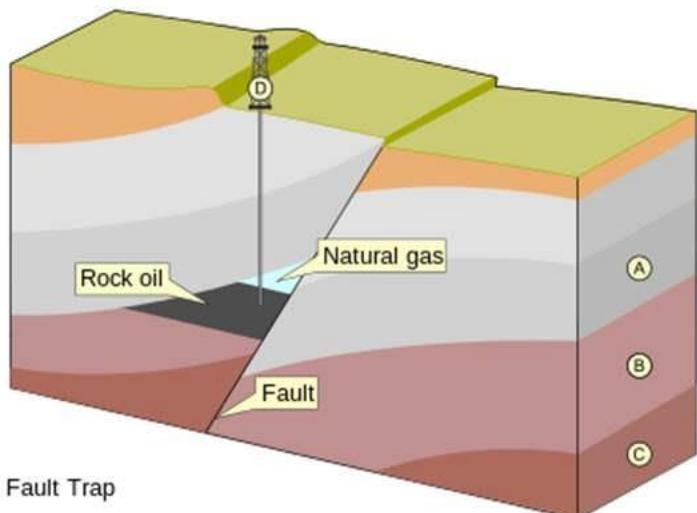
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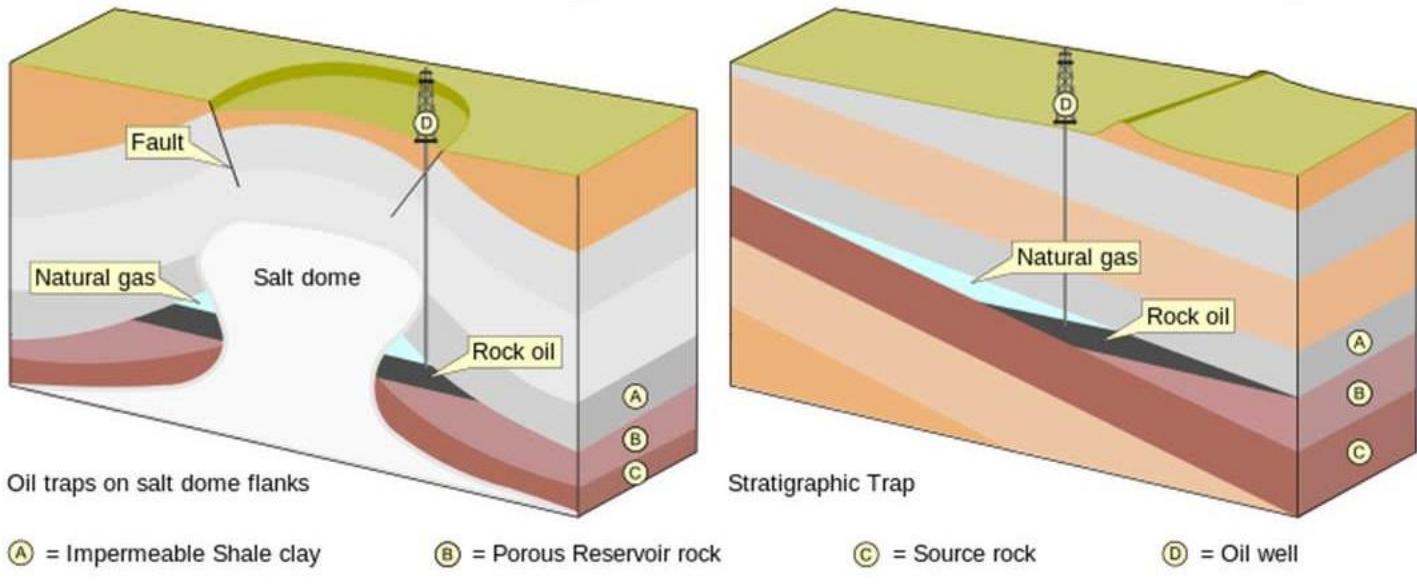
Note: not to scale



Antiklinale Trap



Fault Trap



Oil and Gas traps (MagentaGreen, Wikipedia Commons)

Stratigraphic trap: an impermeable layer capable of retaining hydrocarbons.

Structural traps: cracks in faults and folds that can retain hydrocarbons.

- Common geological traps for hydrocarbons include **shales, salt domes (evaporites; also rich**

in sulphur), and anticlinal folds of permeable and non-permeable strata.

- In addition to liquid hydrocarbons, natural gas is also common.

3.2 Distribution of Petroleum and Mineral Oil in India

- Process of mineral oil formation began in tertiary period (3 million years ago).
- Most of the oil reserves in India are associated with **anticlines and fault traps** in the sedimentary rock formations of tertiary times.
- In **tertiary period, aquatic life was abundant** in various forms, especially the minor microscopic forms of flora and fauna.
- Conditions for oil formation were favourable especially in the lower and middle Tertiary period.

- Dense forests and sea organisms flourished in the **gulfs, estuaries, deltas** and the land surrounding them during this period.

Extent of Oil Bearing Strata in India

- India has 26 sedimentary basins covering an area of 3.36 million square kilometres.
- The Indian sedimentary basins have been broadly divided into three categories:

Type of Basins	Basins / Region:																	
Category I (~10 lakh Km ²)																		
	• Established commercial production. <table border="1"> <thead> <tr> <th>Basin Name</th><th>Estimate (2017) (MMTOE)</th></tr> </thead> <tbody> <tr> <td>1. Mumbai Offshore</td><td>9646</td></tr> <tr> <td>2. Krishna-Godavari (KG)</td><td>9555</td></tr> <tr> <td>3. Assam Shelf</td><td>6001</td></tr> <tr> <td>4. Rajasthan</td><td>4126</td></tr> <tr> <td>5. Cambay (Khambhat Gulf)</td><td>2586</td></tr> <tr> <td>6. Cauvery</td><td>1964</td></tr> <tr> <td>7. Assam-Arakan Fold Belt</td><td>1633</td></tr> </tbody> </table>		Basin Name	Estimate (2017) (MMTOE)	1. Mumbai Offshore	9646	2. Krishna-Godavari (KG)	9555	3. Assam Shelf	6001	4. Rajasthan	4126	5. Cambay (Khambhat Gulf)	2586	6. Cauvery	1964	7. Assam-Arakan Fold Belt	1633
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	Sub-total (Category I)	35511
	MMTOE: million metric tonnes of oil equivalent	
Category II (~7.8 lakh Km²)	Known accumulation of hydrocarbons but no commercial production as yet.	
	1. Saurashtra	1,325
	2. Kutch	898
	3. Vindhyan	632
	4. Mahanadi-North East Coast	651
	5. Andaman-Nicobar	371
	Sub-total (Category II)	3,877
Category III (~15.9 lakh Km²)	Indicated hydrocarbon shows that are considered geologically prospectively.	
	Kerala-Konkan (KK)	1,245
	Bengal-Purnea	828
	Ganga-Punjab	128
	Pranhita-Godavari (PG)	95
	Satpura-South Rewa-Damodar	63
	Himalayan Foreland	44

On-shore Oil Production in India

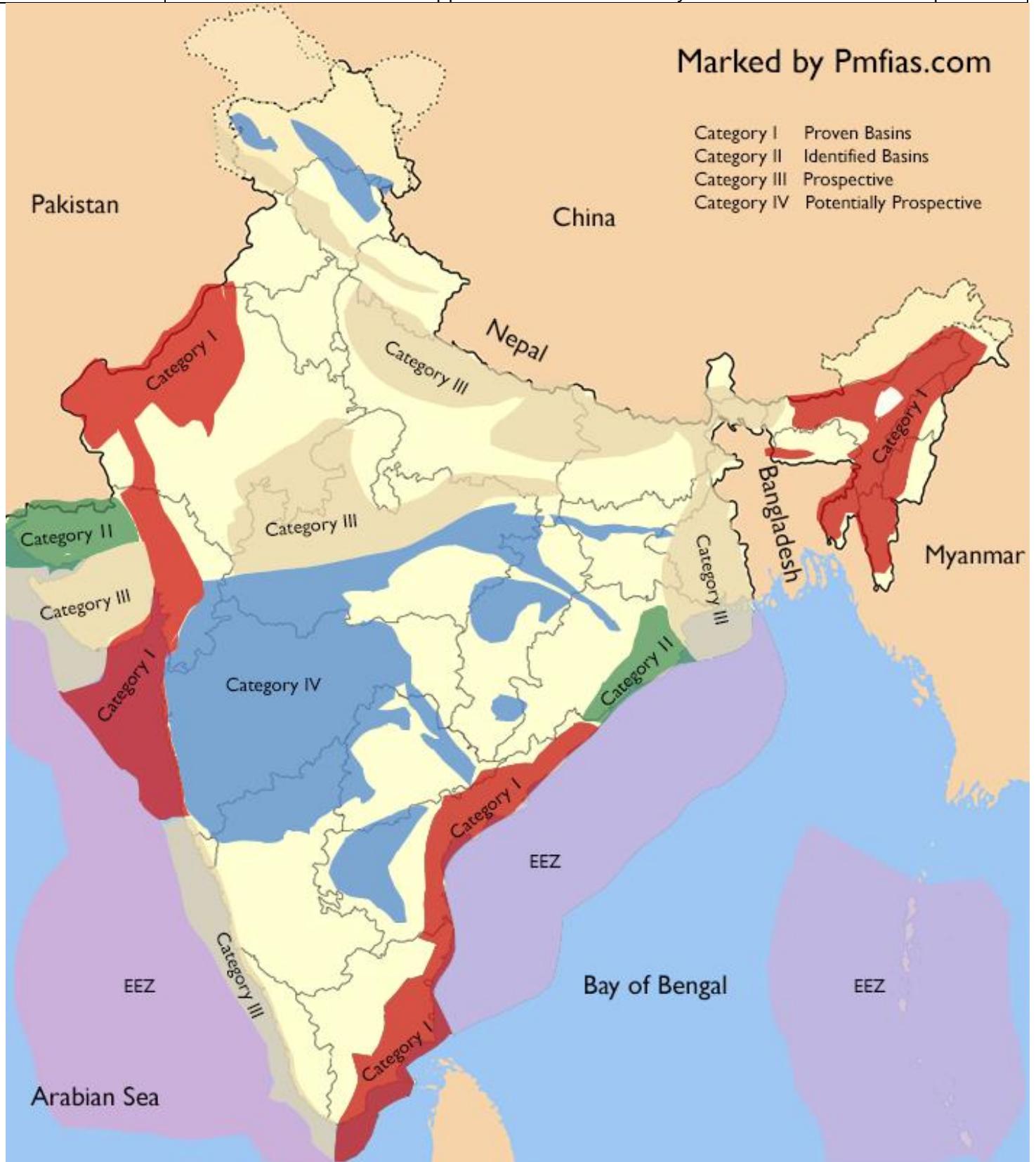
- Brahmaputra valley of north-east India.
- Barmer area of Rajasthan.
- Gujarat coast in western India.
- Cauvery on-shore basin in Tamil Nadu.
- Andhra Pradesh has both on-shore and off-shore oil reserves.

Assam Oilfields	<ul style="list-style-type: none"> • Oldest oil producing state in India. • The Digboi field in Dibrugarh district is the oldest oil field of India. • The Naharkatiya field and The Moran-Hugrijan field are also important. • The main oil bearing strata extend for a distance of 320 km in upper Assam along the Brahmaputra valley. • Oilfields of Assam are relatively inaccessible and are distantly located from the main consuming areas. • Oil from Assam is therefore, refined mostly in the refineries located at Noonamati in Assam (443 km), Digboi, Guwahati, Bongaigaon, Barauni in Bihar (724 km) and Numaligarh.
Gujarat Oilfields	<ul style="list-style-type: none"> • Ankleswar, Khambhat, Ahmedabad, Barkol, and Sanand are important oilfields of this region. • Oil from these fields are sent to refineries at Trombay and Koyali.
Rajasthan Oilfields	<ul style="list-style-type: none"> • Rajasthan is the largest on shore oil producing state of India. • One of the largest inland oil discoveries was made in Barmer district. • Other important discoveries are Mangala oil field, Sarswati and Rajeshwari.

Off-Shore Oil Production in India

Western Coast	<ul style="list-style-type: none"> • Mumbai High, Bassein and Aliabet. • Mumbai High: 1974; rock strata of Miocene age. • Sagar Samrat, Bassein: south of Mumbai High. • Aliabet: Aliabet island is in the Gulf of Khambhat.
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Eastern Coast	<ul style="list-style-type: none"> The basin and delta regions of the Godavari, the Krishna (K-G basin) and the Cauvery rivers hold great potential for oil and gas production. The Rawa field in Krishna-Godavari off-shore basin is an important one. The Narimanam & Kovilappal oilfields in the Cauvery on-shore basin are also important.
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State-wise crude oil and natural gas production trends

State-wise crude oil production trends (thousand metric tonnes)		State-wise natural gas production trends (MMSCMD: Million Metric Standard Cubic Meter Per Day)	
State/Source	2017-18	State/Source	2017-18
Onshore		Onshore	
1. Rajasthan	7887	1. Assam	8.8
2. Gujarat	4591	2. Gujarat	4.4
3. Assam	4345	3. Rajasthan	4
4. Tamil Nadu	345	4. Tripura	3.9
5. Andhra Pradesh	322	5. Tamil Nadu	3.3
6. Arunachal Pradesh	50	6. Andhra Pradesh	2.6
Total Onshore	17540	Total Onshore	29.1
Offshore		Offshore	
Total Offshore	18145	Total Offshore	60.3
Total	35684	Total	89.5

- Offshore production is greater than onshore production

Share of major fuels in Power Generation in India

Total Installed Capacity (As on 31.05.2019)			
Fuel	Giga Watt	% share	
Thermal	Total Thermal	226.3	63.2%
	Coal	194.5	54.3%
	Lignite	6.3	1.7%
	Gas	24.9	7.0%
	Oil	0.64	0.2%
	Hydro (Renewable)	45.4	12.7%
Nuclear		6.8	1.9%
Renewable		79.3	22.0%
Total		357.9	

India's Oil Imports

- Import of crude oil during FY 2017-18 was **220.43 MMT** (INR 5,66,450 crore or **\$87 bn**).

Country	2015-16	2016-17	2017-2018 (MMT – Million Metric Tons)	
Iraq	36.8	37.75	45.74	20.8 %
Saudi Arabia	40.4	39.33	36.16	16.4 %
Iran	12.7	27.14	22.59	10.2 %
Venezuela	23.6	21.43	18.34	8.3 %
Nigeria	23.4	17.7	18.11	8.2 %
UAE	15.7	19.3	14.29	6.5 %

Iraq toppled Saudi Arabia to become the largest crude oil supplier for India.

Imports declined due to US sanctions.

OPEC members reached a deal to cut oil production and boost the market.

Oil Refiners in India

- India's first oil refinery started working way back in 1901 at **Digboi in Assam**.
- In 1954 a refinery was setup at Tarapur (Mumbai).

- Refinery hub and refining capacity exceeds the demand.

Refinery Location	Capacity (MMTPA)*
SEZ, Jamnagar, Gujarat (RIL – private sector)	35
DTA-Jamnagar (RIL – private sector)	33
Vadinar, Gujarat (Essar Oil – private sector)	20
Kochi, Kerala (BPCL)	15
Panipat, Haryana (IOCL)	15
Paradip, Odisha (IOCL)	15
Mangalore, Karnataka (MRPL)	15
Koyali, Gujarat (IOCL)	13
Mumbai, Maharashtra (BPCL)	12
Bathinda, Punjab (JV refineries)	11
Manali, Tamil Nadu (CPCL)	10
Visakhapatnam, Andhra Pradesh (HPCL)	8.3
Mathura, U.P (IOCL)	8
Bina, MP (JV refineries)	7.8
Haldia, West Bengal (IOCL)	7.5

- Excess refined oil and other petroleum products are exported.

Mumbai, Maharashtra (HPCL)	7.5
Barauni, Bihar (IOCL)	6
Numaligarh, Assam (Numaligarh Refinery Ltd.)	3
Bongaigaon, Assam (IOCL)	2.35
Guwahati, Assam (IOCL)	1
Nagapattinam (CPCL)	1
Digboi, Assam (IOCL)	0.65
Tatipaka, AP	0.066
Total	249

- MMTPA: Million Metric Tonne Per Annum
- BPCL: Bharat Petroleum Corporation Limited (Public Sector Units)
- CPCL: Chennai Petroleum Corporation Limited (Public Sector Units)
- HPCL: Hindustan Petroleum Corporation Limited (Public Sector Units)
- IOCL: Indian Oil Corporation Limited (Public Sector Units)

- Mundra-Panipat Pipeline (MPPL)

Petroleum Product Pipelines

- Guwahati-Siliguri Pipeline (GSPL)
- Koyali-Ahmedabad Pipeline (KAPL)
- Barauni-Kanpur Pipeline (BKPL)
- Panipat-Delhi Pipeline (PDPL)
- Panipat-Rewari Pipeline (PRPL)
- Chennai – Trichy - Madurai Product Pipeline (CTMPL)
- Chennai-Bangalore Pipeline
- Naharkatia-Nunmati-Barauni Pipeline → **first pipeline constructed in India**
- Mumbai High-Mumbai-Ankleshwar-Koyali Pipeline.
- Hajira-Bijapur-Jagdishpur (HBJ) Gas Pipeline → **world's largest underground pipeline**
- Jamnagar-Loni LPG Pipeline → **longest LPG pipeline in the world**
- Kochi-Mangalore-Bangalore pipeline
- Vishakhapatnam Secunderabad pipeline
- Mangalore-Chennai pipeline
- Vijayawada-Vishakhapatnam pipeline

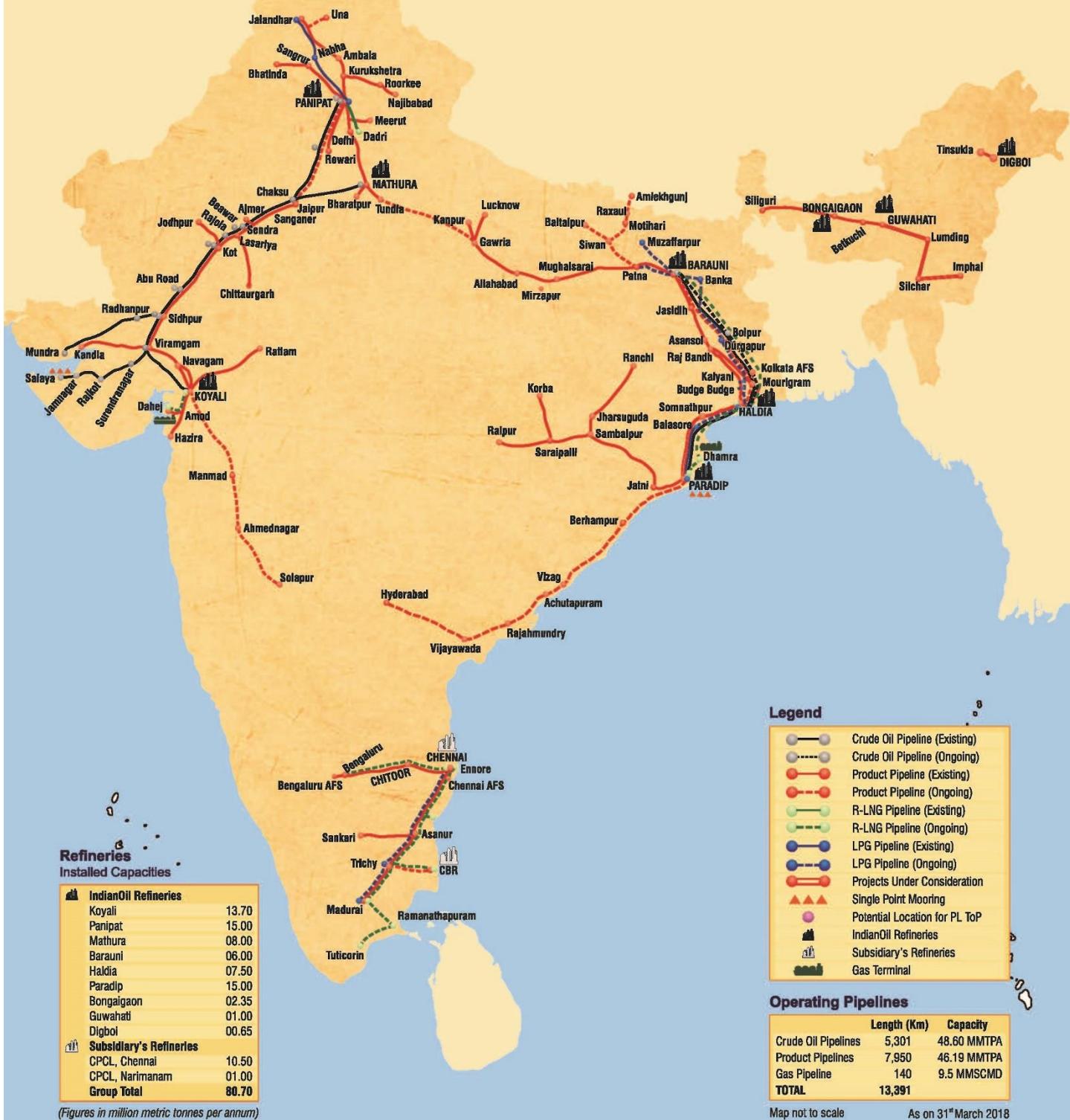
Advantages of Pipeline

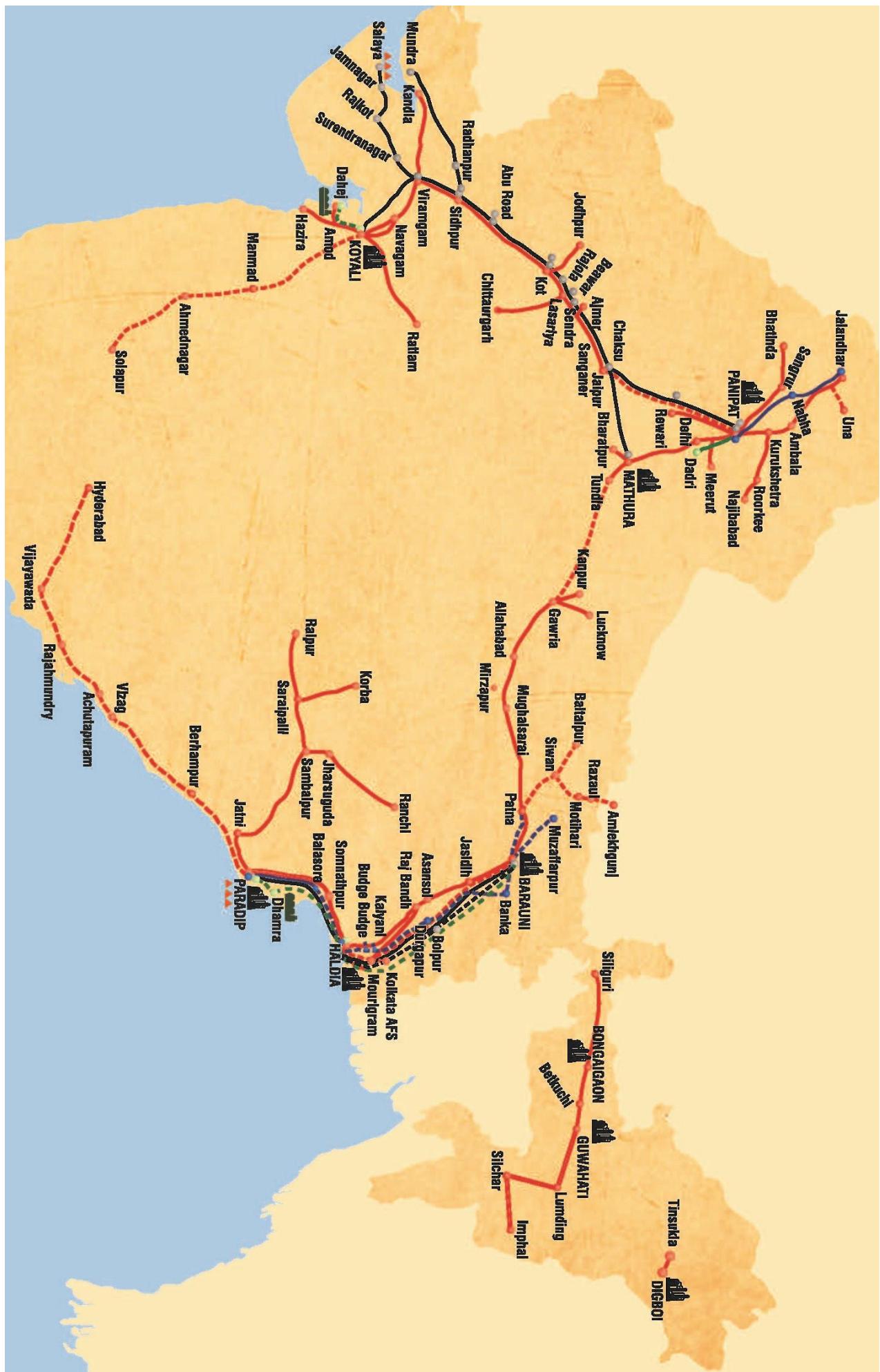


Crude Oil Pipelines

- Salaya-Mathura Pipeline (SMPL)
- Paradip-Haldia-Barauni Pipeline (PHBPL)

IndianOil Group Refineries and Pipelines Network





- Ideal to transport liquids and gases.
- Pipelines can be laid through difficult terrains as well as under water.
- Economical.
- It needs very little maintenance.
- Pipelines are safe, accident-free and environmentally friendly.

Disadvantages of Pipelines

- It is not flexible, i.e., it can be used only for a few fixed points.
- Its capacity cannot be increased once it is laid.
- It is difficult to make security arrangements for pipelines.
- Detection of leakage and repair is also difficult.

3.3 World distribution of Petroleum and Mineral Oil

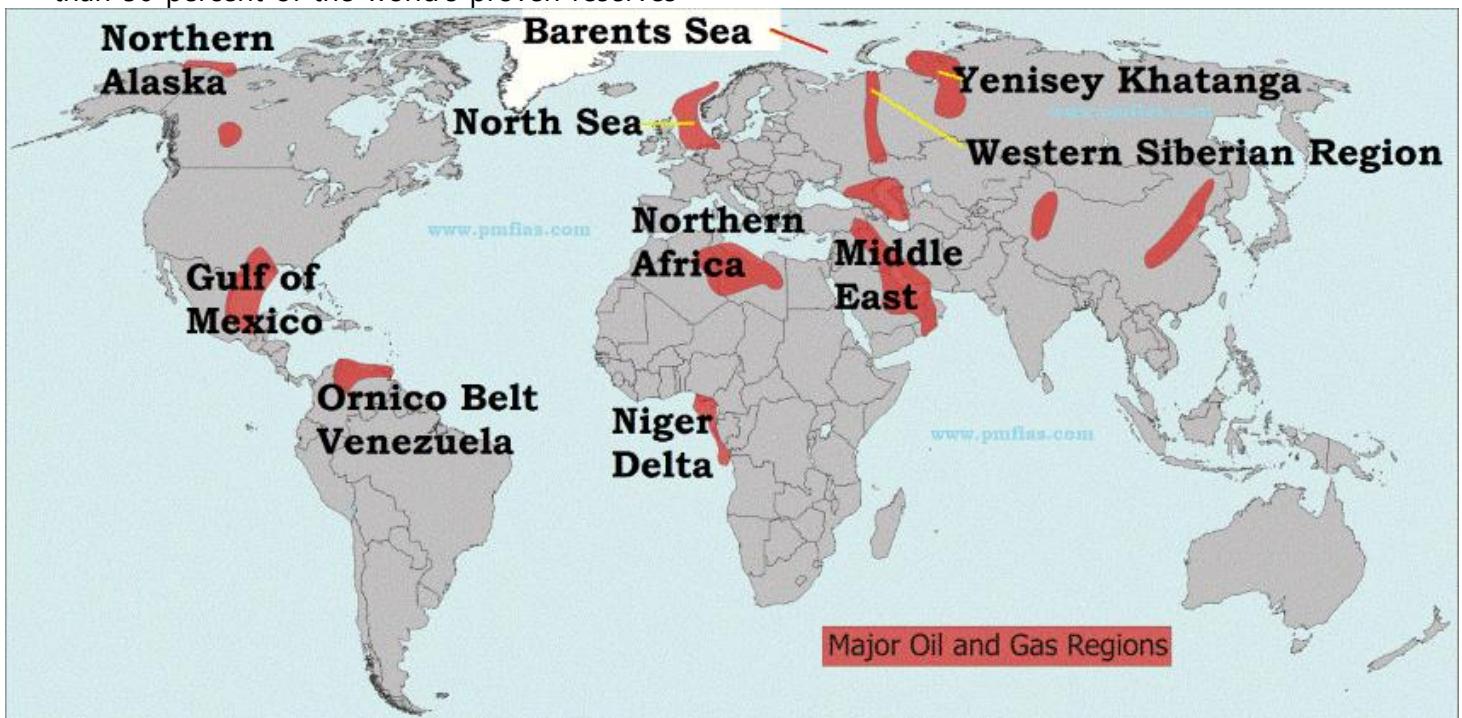
- The amount of oil a given region produces is not always proportionate to the size of its proven reserves.
- For example, the Middle East contains more than 50 percent of the world's proven reserves

but accounts for only about 30 percent of global oil production.

- The United States, by contrast has less than 2 percent of the world's proven reserves but produces about 10 percent of the world's oil.

Supergiants

- Petroleum is contained in a few large fields, but most fields are small.
- The two largest classes of fields are the
 1. **supergiants**, fields with 5 billion or more barrels of ultimately recoverable oil, and
 2. **world-class giants**, fields with 500 million to 5 billion barrels of recoverable oil.
- Fewer than 40 supergiant oil fields have been found worldwide.
- The **Arabian-Iranian sedimentary basin** in the Persian Gulf region contains **two-thirds** of these supergiant fields.
- The remaining supergiants are distributed in the **United States, Russia, Mexico, Libya, Algeria, Venezuela, and China**.



Countries with The Largest Proven Oil Reserves

Country	OPEC member?	Reserves (billions of barrels), 2018
---------	--------------	--------------------------------------

1. Venezuela	Yes	302.8	19 %
2. Saudi Arabia	Yes	267	17 %
3. Canada	NO	170	11 %
4. Iran	Yes	159	10 %
5. Iraq	Yes	145	9 %
6. Kuwait	Yes	101.5	6 %
7. United Arab Emirates	Yes	98	6 %
8. Russia	NO	80	5 %
9. Libya	Yes	48	3 %
10. United States	NO	40	2 %

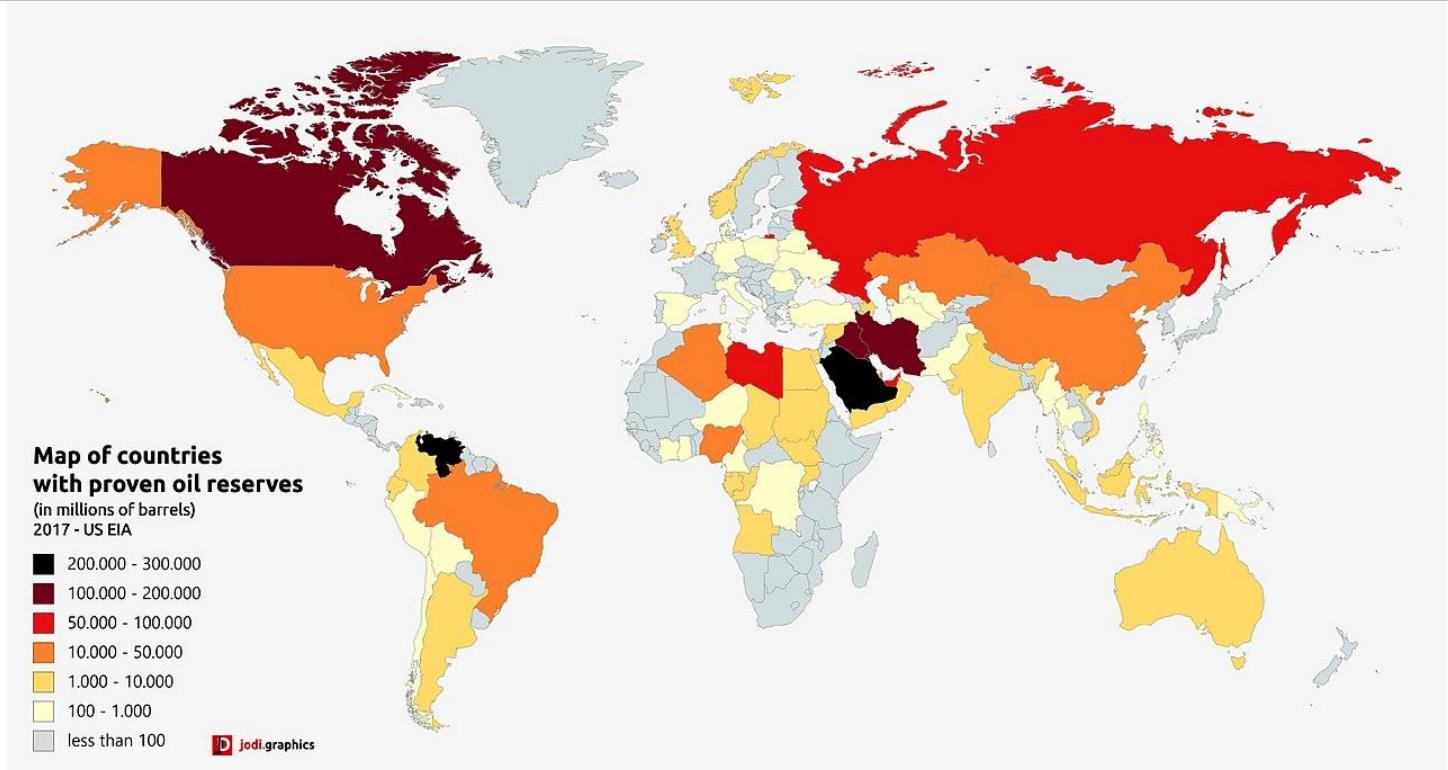


Image Source: [Wikipedia](#)

Saudi Arabia	<ul style="list-style-type: none"> The discovery that transformed Saudi Arabia into a leading oil country was Al-Ghawār oil field. Another important discovery was the Saffaniyah offshore field in the Persian Gulf. It is the third largest oil field in the world and the largest offshore.
Iraq, Kuwait, Iran	<ul style="list-style-type: none"> These countries have a number of supergiant fields. Al-Burqan oilfield of Kuwait is the world's second largest oil field.
Russia	<ul style="list-style-type: none"> Russia is thought to possess the best potential for new discoveries. There are two supergiant oil fields – Western Siberia and Yenisey Khatanga. Kamchatka peninsula and Sakhalin Island are said to have significant oil reserves. Volga-Caspian Region has many oil and gas fields.
North America	<ul style="list-style-type: none"> North America has many sedimentary basins. Many oilfields have been found in North Slope region of Alaska and East Texas. The Rocky Mountain region contains an enormous amount of petroleum reserve. Canada has huge deposits of oil sands in the Athabasca region in western Canada Canada's largest oil field is off Newfoundland.
Venezuela	<ul style="list-style-type: none"> Venezuela is the major oil exporter in the Western Hemisphere.

	<ul style="list-style-type: none"> Most of the country's reserves are located in the Orinoco belt.
Western Europe	<ul style="list-style-type: none"> Significant oil reserves are found in North Sea. Exploration in the Barents Sea has been of great interest.
Africa	<ul style="list-style-type: none"> The main oil-producing countries of Africa are Libya, Algeria, Nigeria and Egypt. Niger delta in Nigeria contains enormous amount of oil. Egypt is self-sufficient in oil production. Algeria is another significant producer of petroleum where much of the national income comes from oil-export. Libya became a consistent producer of petroleum.

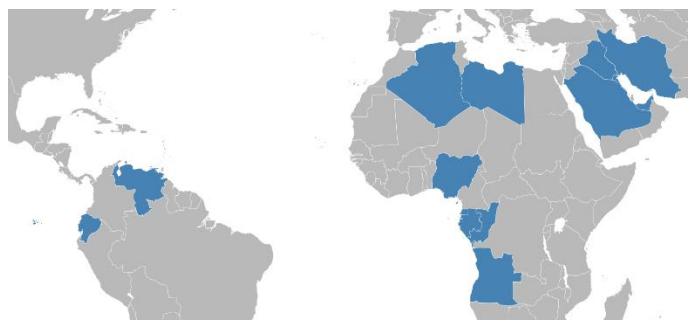
World's Top Producers, Consumers and Exporters of Oil

Top Crude Oil Producers (2018)			Top Crude Oil Consumers (2017)			Top Crude Oil Exporters (% share)
Country	Million barrels/day	Country	Million barrels/day	Country	Million barrels/day	
1. USA	17.8	18%	1. USA	19.8	20%	1. Saudi Arabia (16 %)
2. Saudi Arabia	12.4	12%	2. China	12.7	13%	2. Russia: (11 %)
3. Russia	11.4	11%	3. India	4.6	5%	3. Iraq (8.1%)
4. Canada	5.2	5%	4. Japan	3.9	4%	4. Canada (5.9%)
5. China	4.8	5%	5. Russia	3.2	4%	5. UAE (5.2%)
India (11 th place)	2.5	3%				

OPEC – Organization of Petroleum Exporting Countries

- OPEC is a 14 member oil supply cartel.
- It is founded by the first five members (Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela).
- This group bargains with international Oil Companies to maximize their profit margin.
- They control production and supply of crude oil to keep it below international demand.
- The current OPEC members are the following: Algeria, Angola, Ecuador, Equatorial Guinea, Gabon, **Iran, Iraq, Kuwait, Libya, Nigeria**, the

Republic of the Congo, **Saudi Arabia, United Arab Emirates**, and **Venezuela**. Indonesia and Qatar are former members.



4. Natural gas

- Natural gas consists of primarily **methane** and **ethane**. (LPG is a mixture of **butane and propane**)
- Propane, butane, pentane, and hexane are also present.
- Natural gas is formed during the process of formation of Petroleum.
- Hence, it is often found dissolved in oil or as a gas cap above the oil.
- Sometimes, pressure of natural gas forces oil up to the surface. Such natural gas is known as **associated gas or wet gas**.
- Some reservoirs contain gas and **no oil**. This gas is termed **non-associated gas or dry gas**.
- Often natural gases contain substantial quantities of **hydrogen sulphide** or other organic sulphur compounds. In this case, the gas is known as "**sour gas**."

- Coalbed methane is called '**sweet gas**' because of its lack of hydrogen sulphide.

Oil + Gas → Associated Gas or Wet Gas,
Only Gas → Non-Associated Gas or Dry Gas,
Hydrogen Sulphide in gas → Sour Gas,
Coalbed Methane → Sweet Gas.

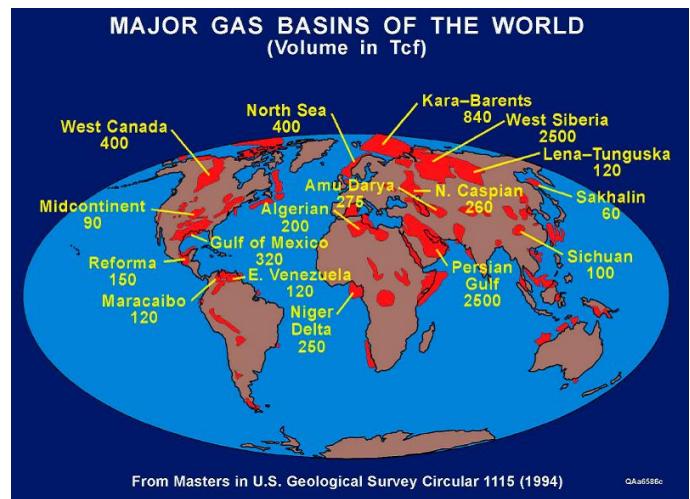
- On the market, natural gas is usually bought and sold not by volume but by **calorific value**.
- In practice, purchases of natural gas are usually denoted as MMBTUs (millions of British thermal units – BTU or Btu) = ~1,000 cubic feet of natural gas.

Uses of Natural Gas

- Electric power generation.
- Many buses and commercial vehicles now operate on Compressed Natural Gas (CNG).
- Ammonia** is manufactured using hydrogen derived from methane.

- Ammonia is used to produce chemicals such as nitric acid, urea, and a range of fertilizers.

4.2 Distribution of Natural Gas across Indian and the World



Top natural gas producers, consumers, and countries with highest reserves

Proven Reserves 2018 (Trillion m ³)		Production 2018 (Billion m ³)		Consumption 2018 (Billion m ³)	
Country	Reserves	Country	Production	Country	Consumption
1. Russia	47.8	1. United States	864	1. United States	848
2. Iran	33.7	2. Russia	741	2. Russia	505
3. Qatar	24	3. Iran	232	3. China	275
4. United States	15	4. Canada	188	4. Iran	219

Leading exporters: **Russia, Qatar, Norway**
 Leading Importers: China, Japan, European Union countries like **Germany, Italy, etc.**

- India proven gas reserves of **1.3 Billion m³**.
- Indian consumed only 55 Billion m³ of natural gas in 2018.

Russia	<ul style="list-style-type: none"> Some of the world's largest gas fields occur in a region of West Siberia and east of the Gulf of Ob on the Arctic Circle. The world's largest gas field is Urengoy. Volga-Urals region also has significant gas reserves.
North America	<ul style="list-style-type: none"> The largest gas field of United States, Hugoton, extends through the Oklahoma, Texas and Kansas. Canada's largest gas field is in Alberta. Much of Mexico's natural comes from Gulf of Mexico.
Europe	<ul style="list-style-type: none"> Dutch coast and the North Sea (off the coast of Norway) have proven reserves. Norway and Netherlands are the leading producers in the region.
Africa	<ul style="list-style-type: none"> Central basin of Algeria and Niger Delta have proven reserves.
Middle East	<ul style="list-style-type: none"> There is an enormous gas potential in the Middle East associated with the major oil fields

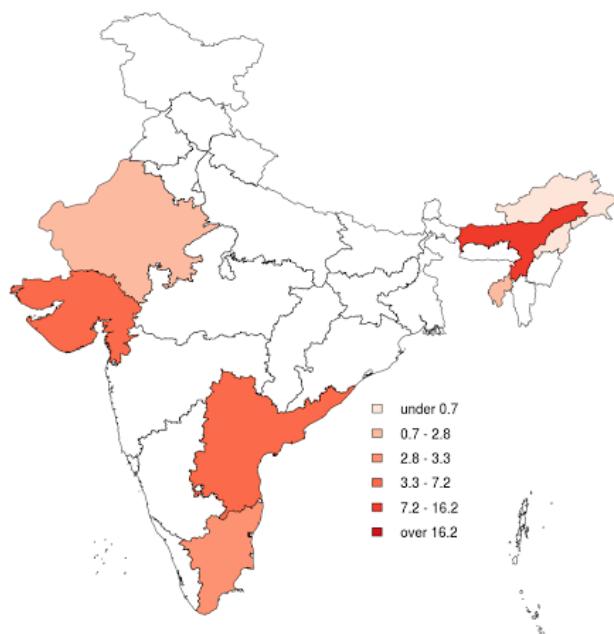
	<p>in the Arabian-Iranian basin.</p> <ul style="list-style-type: none"> Iran and Qatar significant proven natural gas reserves in the world.
Asia	<ul style="list-style-type: none"> The largest gas field in Asia is in the North Sumatra basin of Indonesia. Malaysia and Indonesia combined have significant gas reserves.
India	<ul style="list-style-type: none"> KG basin, Assam, Gulf of Khambhat, Cuddalore district of Tamil Nadu, Barmer in Rajasthan etc.

Domestic Allocation and Supply of Natural Gas

Domestic Natural Gas and (ii) Imported Re-gasified Liquefied Natural Gas (R-LNG).

Sector	Domestic	R-LNG	Total
Fertilizers	22.04	20.51	42.55
Power	24.73	7.44	32.17
City gas distribution	11.55	8.12	19.67

Distribution% of Natural Gas Reserves - as of 31st March 2011



Petroleum – Value Chain

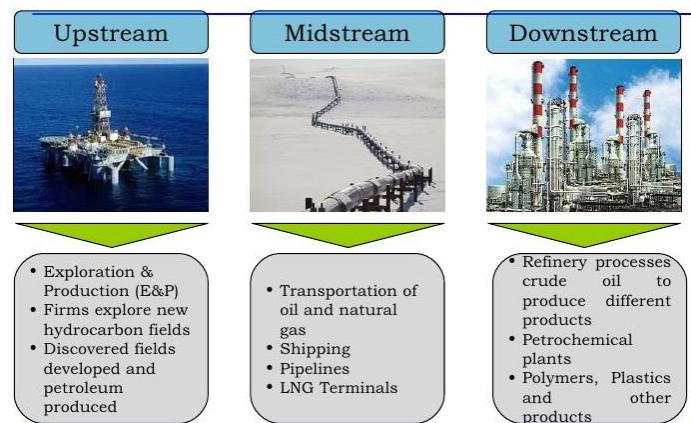
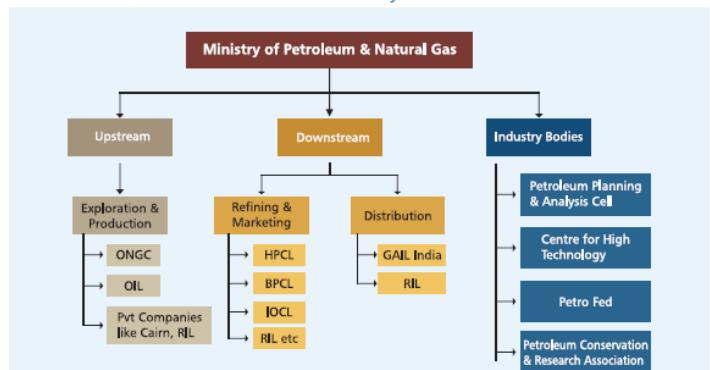


Exhibit 3.1: Structure of Indian Oil & Gas Industry



Source: Ministry of Petroleum & Natural Gas

4.3 Petroleum and Gas Value Chain

- Oil & gas industry is divided in Upstream, Mid-stream and Downstream sector.

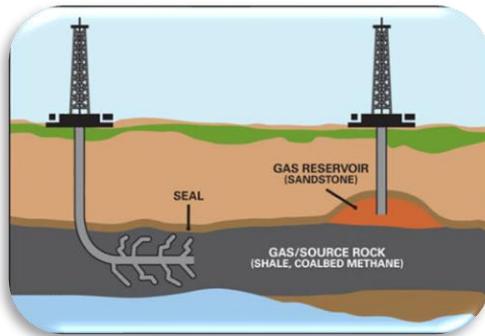
5. Unconventional Gas Reservoirs

- Conventional reservoirs of oil and natural gas are found in **permeable sandstone**.
- Unconventional Gas Reservoirs occur in **relatively impermeable sandstones**, in joints and fractures or, absorbed into the matrix of shales

(shale is a **sedimentary rock**), and in **coal seams**.

- Examples of unconventional gas resources:** **Tight gas, shale gas, and coal-bed methane.**

- Extraction of unconventional gas requires specialized technology which is expensive & complex to develop.



Unconventional Gas Reservoir

5.1 Coalbed Methane

- Considerable quantities of **methane** is trapped within coal seams (underground coal deposits).
- A significant portion of this gas remains as free gas in the **joints and fractures of the coal seam**.
- Large quantities of gas are adsorbed on the internal surfaces of the micropores within the coal itself.
- This gas can be accessed by drilling wells into the coal seam and **pumping large quantities of water** that saturate the seam (water will occupy the gaps and pores and will push out the gas).
- Coalbed methane is now becoming an important source of **natural gas**.
- Unlike much natural gas from conventional reservoirs, coalbed methane contains **very little heavier hydrocarbons** such as **propane or butane**.
- The presence of this gas is well known from its occurrence in underground coal mining, where it presents a **serious safety risk**.

*Fire Accidents in Coal Mines are mainly due to **Coalbed Methane**, and **Lignite deposits** (undergo spontaneous combustion).*

- With one of the largest proven coal reserves, and one of the largest coal producers in the world, India holds significant prospects for commercial recovery of coalbed methane.
- It is estimated that India may produce about 5.5 million standard cubic meters of CBM by the end of 2018.
- At present, in many coal mines, coal mine methane is not trapped and is blown out.
- At present CBM is produced from some virgin coal mines – **Jharia in Jharkhand, Raniganj East and South in West Bengal and Sohagpur West in Madhya Pradesh**.

State	Estimated CBM Resources (BCM)
1. Jharkhand	722
2. Rajasthan	360
3. Gujarat	351
4. Orissa	243
5. Chhattisgarh	240
6. Madhya Pradesh	218
7. West Bengal	218
Total CBM Resources	GOI has identified CBM Resources of 2,600 billion cubic meters (91.8 TCF) .

Problems in Exploration, Extraction of Coalbed Methane in India

- The state-run firms are holding mines in joint venture with private companies and **the latter do not have rights to explore unconventional gas resources** — coalbed methane, shale gas, tight gas.
- CBM extraction falls under **Ministry of Petroleum & Natural Gas** whereas coal mining falls under **Ministry of Coal**.
- Hence, contractors are not allowed to mine gas from coal seams or coal bed methane (CBM) and coal in the same block due to the **turf war** between the two ministries and other associated bureaucratic hurdles.
- The technology required is very advanced and the public sector companies have very weak or-

Coalbed Methane in India

organizational setup to efficiently handle such technologies and extract gas economically.

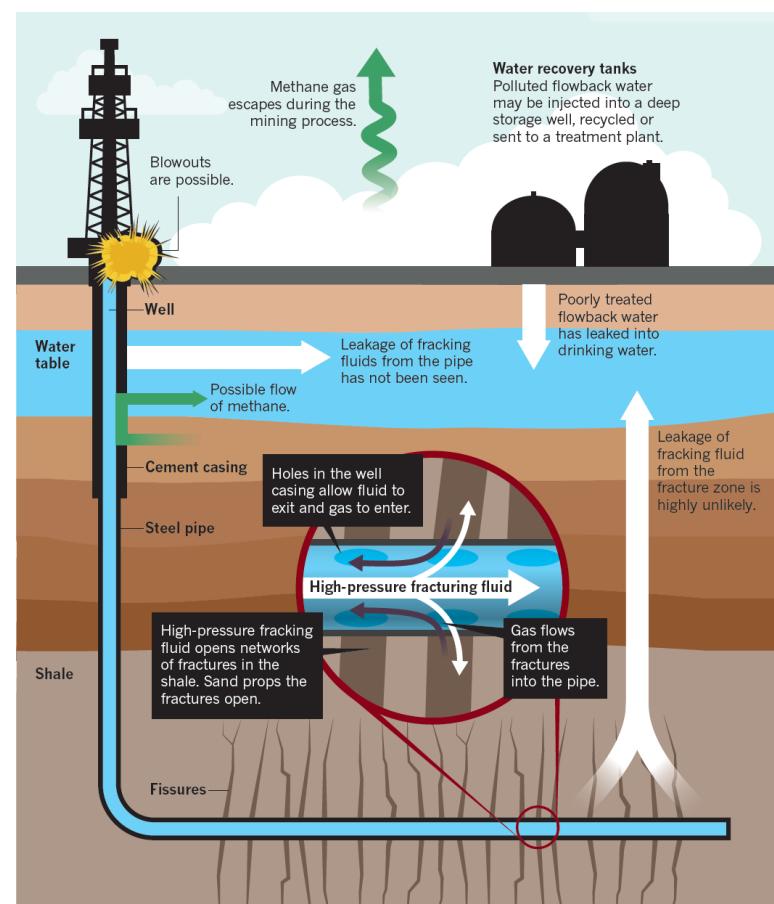
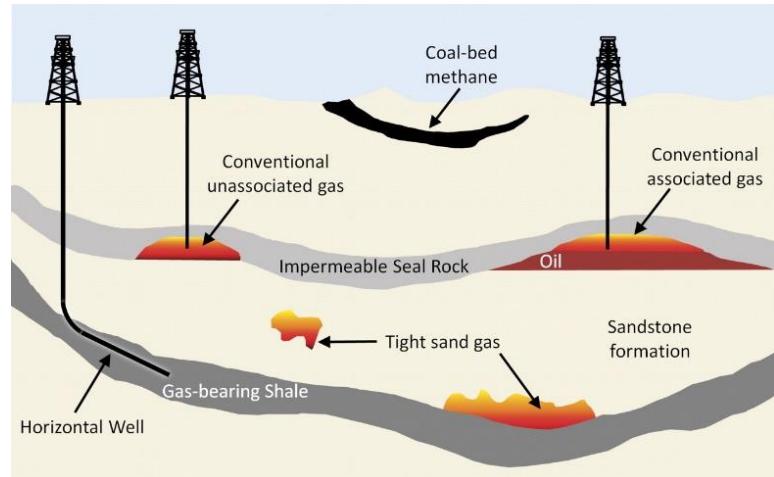
- Private sector companies have necessary financial capabilities and managerial skills but there is no hope due to restricting laws and low gas prices.

5.2 Shale Gas

- Shale gas is a mixture of lot of **methane** + little **ethane, propane, & butane** + very little **carbon dioxide, nitrogen, and hydrogen sulfide**.
- Shales are **fine-grained sedimentary rocks** formed of organic-rich mud at the bottom of ancient seas.
- Subsequent sedimentation and the resultant heat and pressure transformed the mud into shale and also produced natural gas from the organic matter contained in it.
- Over long spans of geologic time, some of the gas migrated to adjacent **sandstones** and was trapped in them, forming conventional gas accumulations.
- The rest of the gas remained **locked** in the **nonporous shale**.

Extraction of Shale Gas

- Different types of sedimentary rocks contain natural gas, for example **sandstones, limestones and shales**.
- Sandstone rocks often have **high permeability**, which means that the tiny pores within the rock are well connected and gas can flow easily through the rock.
- In contrast, shale rocks where gas is trapped as a continuous accumulation throughout a large area usually have **very low permeability**, making gas production more complex and costly.
- Shale gas occurs frequently at depths exceeding 1,500 metres (5,000 feet).
- Extraction is done through **horizontal drilling** through the shale seam, followed by **hydraulic fracturing, or fracking**, of the rock by the **injecting fluid at extremely high pressure**.



Hydro-fracturing or Fracking

- Shale rock is sometimes found 3,000 metres below the surface.
- After deep vertical drilling, there are techniques to **drill horizontally** for considerable distances in various directions to extract the gas-rich shale.
- A **mixture of water, chemicals, and sand** is then injected into the well at very high pres-

sures to create a number of fissures in the rock to release the gas.

- The process of using water for breaking up the rock is known as '**hydro-fracturing**' or '**fracking**'.
- The chemicals help in water and gas flow and tiny particles of **sand enter the fissures to keep them open** and allow the gas to flow to the surface.

Guar gum

- Guar gum can quickly turn water into a **very thick gel**.
- Adding guar gum **increases viscosity of water** and **makes high-pressure pumping and the fracturing process more efficient**.
- High viscosity water is much more effective at suspending sand grains and carrying them into the fractures.
- The guar bean is grown mainly by farmers in **Rajasthan** and **Haryana**.
- Earlier, guar gum was used mainly as an additive in ice creams and sauces.
- But with the discovery of its use in shale gas extraction, its **price shot up enormously**.

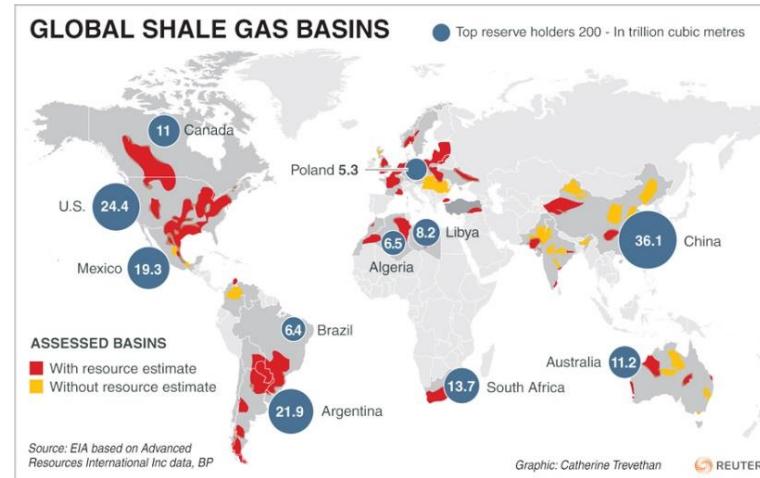
Country	Shale gas reserves (in TCF)	Technically recoverable Shale gas reserves (in TCF)
1. China	1275	1,115
2. USA	862	623
3. Argentina	774	802
4. Mexico	681	545
5. South Africa	485	390
India	100-200 TCF	World Total 7576

- Till 2000, there has been almost nil shale gas production in the United States, but now it is the pioneer country in shale gas production.
- China has the largest reserves, yet the production is low.
- In India, probable Shale gas resources are in the range of 100-200 TCF in 5 Indian sedimentary basins.
- ONGC predicts 187.5 TCF of shale gas in **Cambay Onland, Ganga Valley, Assam & Assam-Arakan, Krishna Godavari (KG) Onland, Cauvery Onland & Rajasthan & Vindhya Basins**.
- Indian engineers have gathered experience on fracking by spending time in the US and are

Problems associated with shale gas exploitation

- Environmentalists have objected to fracking because of the **damage to forest cover and possible contamination of ground water**.
- However, industry officials say that the treated water can be **re-used** for further fracking and need not be disposed of at all.

Shale Gas Reserves across India and the World

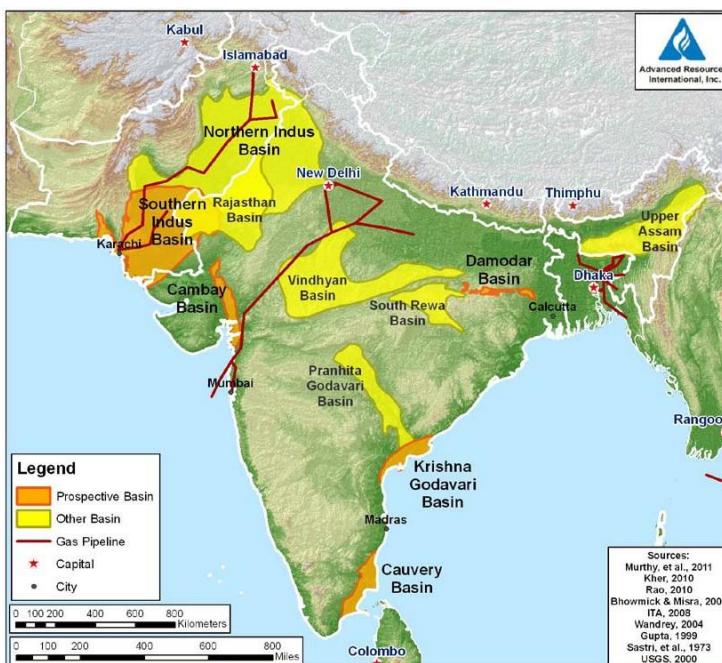


now able to hunt for the scarce resource on their own.

Shale Gas Extraction Issues in India – If US can then why can't India?

- India suffers from **water scarcity** whereas the U.S. do not have the same water worries.
- In the US, the natural gas department is exempt from scrutiny for chemical injection in the ground (companies need not disclose the chemicals used during hydraulic fracturing). There is no such legislation in India.

- In US, the citizen or resident owns the resources that lie beneath the ground. In India, soil below the land is a public property and the companies must follow all the necessary rules to acquire it.
- The US has mapped all its shale reserves. In India there is no clarity on the exact recoverable shale reserves.
- The population density is much lower in the US and they can afford to do it.
- Government-issued leases for conventional petroleum exploration do not include unconventional sources such as shale gas.
- All locations in US is well connected with gas pipelines. Bulk of the reserves in eastern India lack the necessary network of pipelines to transport the gas.



Shale Gas: Low Potential, High Risk and India has a Better Alternative

- India has [315 billion tonnes](#) of coal lying under its soil.
- Extraction is complicated because of environmental issues.
- But, '**underground coal gasification**', can create 6,900 TCF of gas which is way **higher** than shale reserves.
- India's shale resources at a more modest 100-200 TCF. On the other hand, India's CBM poten-

tial is estimated at 450 TCF (91 TCF proven reserves).

- **Coal bed methane (CBM)**, in terms of depth, occurs much closer to the land surface than shale gas and hence it is comparatively easier to extract.
- So, focus must be on CBM exploration rather than on risky shale business.

Mains 2013: It is said that India has substantial reserves of shale oil and gas, which can feed the needs of the country. However, tapping of resources does not appear to be high on the agenda. Discuss critically the availability and issues involved. (10 marks - 200 words)

Answer Yourself with the help of above points.

5.3 Tight Gas

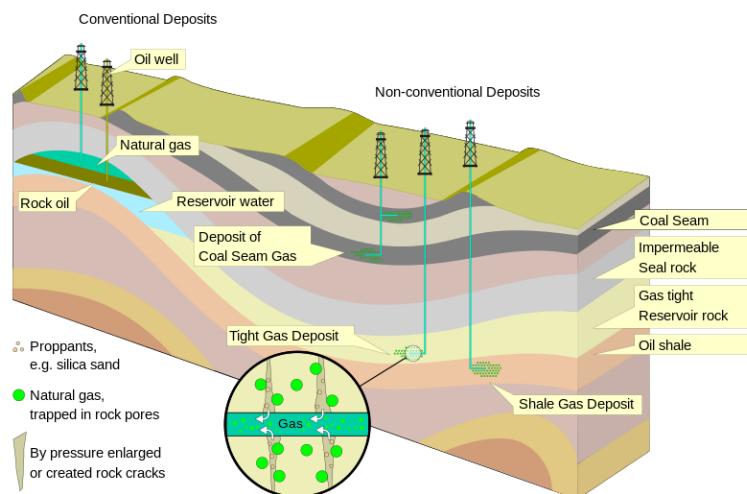


Image credits: [Wikipedia](#)

- Tight gas is natural gas produced from reservoir **rocks of low permeability**.
- Just like shale gas, it has to be extracted by massive **hydraulic fracturing**.
- The difference between shale gas and tight gas is that, shale is trapped in **sedimentary shale rocks** whereas **tight gas is found trapped in sandstone or limestone formations with relatively low permeability**.
- Few countries like USA, Canada, China and Australia are the pioneers in the development of tight reservoirs.

- Tight reservoirs occur in almost all the producing basins of India and in frontier basins viz. Bengal & Vindhyan basin.
- Exploration of tight reservoir has already started in KG-PG, Cauvery and Cambay basins

6. Bauxite

- Bauxite ore is the primary source of aluminium.
- It forms when laterite soils are severely leached of soluble materials in a wet tropical or subtropical climate.
- The ore is chemically processed to produce aluminium oxide.
- Aluminium oxide is then smelted using electrolysis to produce aluminium metal.

6.1 Bauxite Distribution in India

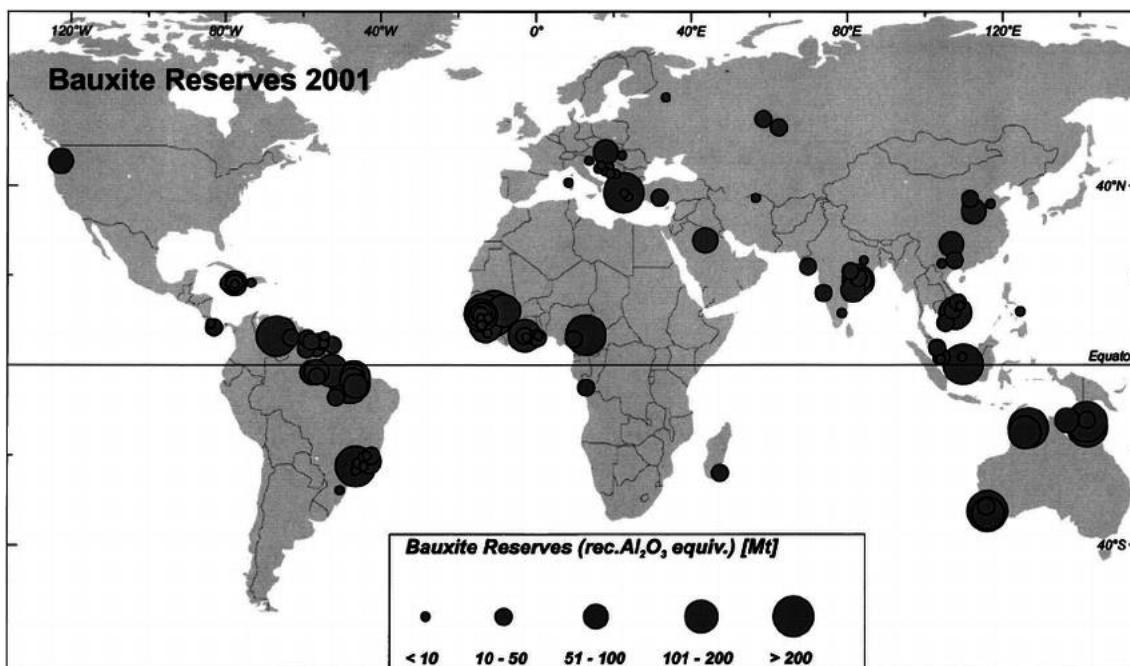
- Reserves of bauxite in India as of 2015, have been placed at 3.9 BT (77% metallurgical grade).

Bauxite Reserves in India		Bauxite Production in India		
State	% share	State	Production (MT) 2017-18	
1. Odisha	51%	1. Odisha	7.8	52%
2. Andhra Pradesh	16%	2. Jharkhand	2.1	14%
3. Gujarat	9%	3. Chhattisgarh	2	13.3%
4. Jharkhand	6%	4. Gujarat	1.6	10.7%
Total	3.9 BT	Total	15 MT	



Odisha	<ul style="list-style-type: none"> Largest bauxite producing state. Major mines: Koraput, Kalahandi and Rayagada districts. Others: Sundargarh, Bolangir and Sambalpur districts. The deposits extend further into the state of Andhra Pradesh.
Chhattisgarh	<ul style="list-style-type: none"> Second largest producer. Maikala range in Bilaspur, Durg districts and the Amarkantak plateau regions of Surguja, Raigarh and Bilaspur are some of the areas having rich deposits of bauxite.
Maharashtra	<ul style="list-style-type: none"> Third largest producer. Largest deposits occur in Kolhapur district. Kolhapur district contain rich deposits with alumina content 52 to 89 per cent. Other districts: Ratnagiri, Thane, Satara and Pune.
Jharkhand	<ul style="list-style-type: none"> Ranchi, Lohardaga, Palamu and Gumla districts. High grade ore occurs in Lohardaga.
Gujarat	<ul style="list-style-type: none"> The most important deposits occur in a belt lying between the Gulf of Kachchh and the Arabian sea through Jamnagar, Bhavnagar, Junagadh and Amreli districts.
Madhya Pradesh	<ul style="list-style-type: none"> Amarkantak plateau area, the Maikala range in Shandol, Mandla and Balaghat districts and the Kotni area of Jabalpur district are the main producers.
Tamil Nadu	<ul style="list-style-type: none"> Nilgiri and Salem are the main bauxite producing districts.

6.2 Bauxite Distribution across the World



[World's Bauxite Reserves: Source and Credits](#)

World's Bauxite Reserves		World's Bauxite Production	
Country	Reserves (BT)	Country	Production (MT)
1. Guinea	7.4	1. Australia	89
2. Australia	6	2. China	65
3. Vietnam	3.7	3. Guinea	47
4. Brazil	2.6	4. Brazil	38
Total	~ 30 BT	5. India	15

- **Australia:** Cape York Peninsula, Northern Territory, Western Australia. Each of these countries have enough reserves to continue production for decades to come.
- India's bauxite ore reserves are estimated to be **660 MT**.

7. Lead & Zinc

7.1 Lead

- Lead is a **corrosion-resistant, ductile** (can be drawn out into a thin wire) and **malleable** (can be hammered into shape without breaking) blue-grey metal. It is a **bad conductor**.
- It is a heavy metal that is **denser** than most common metals and also has a **relatively low melting point**.
- **Galena (lead glance – natural mineral form of lead sulphide)**, a principal ore of lead, often bears silver.
- Galena is found in veins in limestones, calcareous slates and sandstones.
- Lead is easily extracted from its ores.
- Lead effectively **resists corrosive effects of atmospheric gases and acidic substances**.
- Hence it is largely used for coating iron-sheets, lining acid tanks etc.
- World-wide largest single use of lead today is in the manufacture of lead-acid storage batteries.
- Other major uses of lead are in the manufacture of storage batteries, paints, ammunition, etc.
- It is alloyed with many other metals to produce brass, bronze (**anti-friction metal**), etc.

- It is also used as **plumbing material** in automobiles, aero planes, electric wires, etc.

7.2 Zinc

- Zinc is a silvery blue-grey metal with a relatively low melting and boiling point.
- **Sphalerite (zinc sulphide)** is the principal ore of zinc.
- It is usually found in veins in association with **galena, pyrite (iron disulphide), and other sulphides**.
- About three-fourths of zinc is used as coating to protect iron and steel from corrosion (**galvanized steel**) and as alloying metal to make **bronze and brass**.
- The remaining one-fourth is consumed as zinc compounds mainly by the rubber, chemical, paint, and agricultural industries.
- Zinc is also a necessary element for proper growth and development of humans, animals, and plants.
- It is the **second most common trace metal, after iron, naturally found in the human body**.

7.3 Distribution of Lead and Zinc ores – India and World

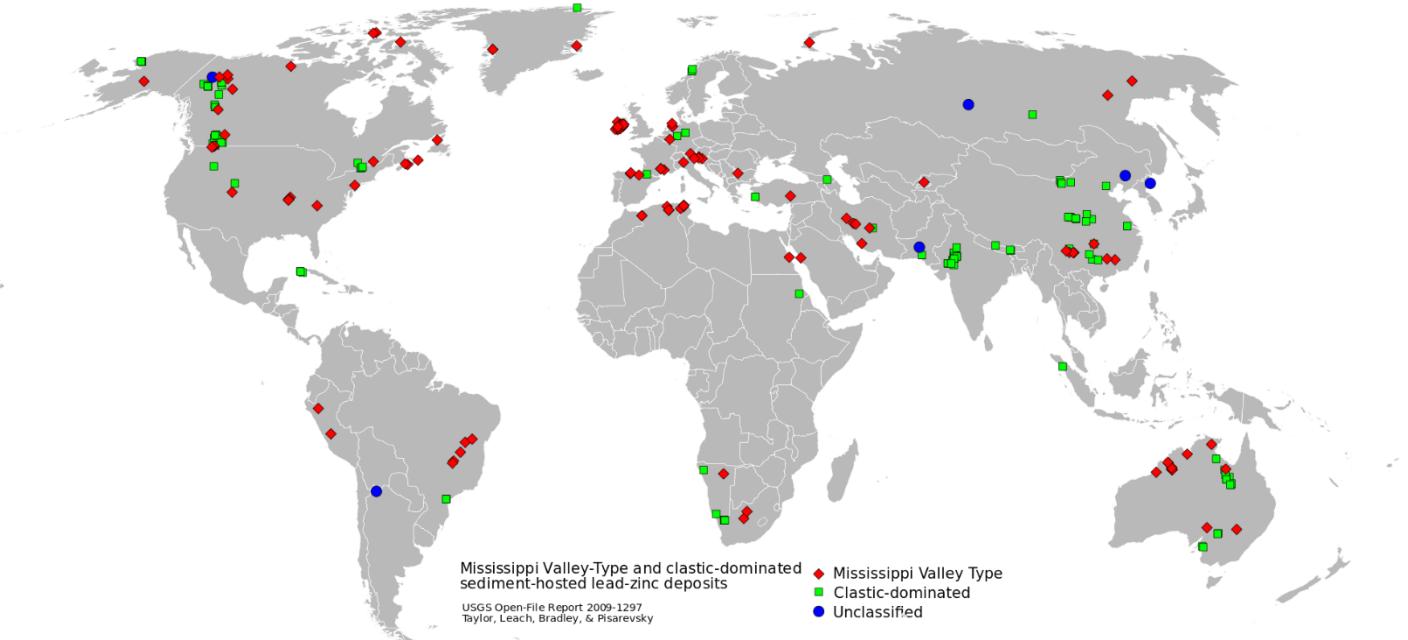
World's Lead Reserves (in MT)		World's Lead Production (in thousand tons)		World's Zinc Reserves (in MT)		World's Zinc Production (in thousand tons)	
Country	Reserves	Country	Year 2017	Country	Reserves	Country	Year 2017
1. Australia	24	1. China	2300	1. Australia	64	1. China	4300
2. China	18	2. Australia	459	2. China	44	2. Peru	1473
3. Russia	6.4	3. Peru	307	3. Peru	21	3. Australia	841
World Total	83 MT	India	173	World	230 MT	4. India	784

- **Indian has 2.5 MT of lead and 10 MT of zinc reserves.**
- Both lead & zinc are found to occur together in ore along with other metals like **silver** and **cadmium**.

- The country has the self-sufficiency in respect of zinc. In contrast, there is short supply of lead.
- Almost the entire production of zinc and lead comes from **Rajasthan**.

- The demand for lead from Lead Acid Battery Sector is met by the thriving market of lead scrap recycling.
- Hindustan Zinc Ltd (Rajasthan)** is the only producer of primary lead and primary zinc in 2017-18.
- Edayar (Binani) Zinc Limited did not operate pursuant to repealing of Sick Industrial Companies.

State	Reserves (MT)		Major Mines in Rajasthan
1. Rajasthan	670	89%	<ul style="list-style-type: none"> Rampura-Agucha mine (Bhilwara district), Kayad mine (Ajmer district), Rajpura-Dariba and Sindedar-Khurd mine (Rajsamand district) and Zawar group of mines (Udaipur district),
2. Andhra Pradesh	22.7	3%	
3. Madhya Pradesh	14.8	2%	
4. Bihar	11.4	1.5%	
5. Maharashtra	9.3	1.24%	



7.4 Pyrites

- Sulphur is used for the production of sulphuric acid which in turn is used for the production of chemical fertilizers, textiles, galvanising of steel, storage batteries, refining of petroleum, explosives and other acids.
- Elemental sulphur is useful for manufacturing explosives, matches, insecticides and for vulcanizing rubber.
- It can be found as a pure element or as sulphate or sulphide minerals.
- Pyrite is a **sulphide of iron** that occurs in sedimentary rocks. It is a chief source of **sulphur**.
- Sulphide occurs naturally in mineral ores, oil and coal deposits.

- Native sulphur deposit has been reported in **Puga Valley** of Leh district in Jammu & Kashmir.
- Petroleum refineries extract H₂S when making "clean fuels" and use it as a feed stock to produce sulphur.
- High proportion of sulphur is injurious to iron. Hence it is removed and used to produce sulphur.
- Total reserves of pyrites in the country as of 2015 have been placed at 1.7 BT.
- Out of these, only about 27 million tonnes are under feasibility category.
- Major reserves are located in Bihar (94%) and Rajasthan (5%).

- Entire native resources of sulphur are located in Jammu & Kashmir (100%) and are placed at 0.21 MT.
- China, USA and Canada have the highest reserves.
- India's imports of sulphur were mainly from UAE (30%), Qatar (28%), Saudi Arabia (22%).

8. Gold and Silver

8.1 Gold

- Gold in its purest form is dense, soft malleable and ductile metal.
- It is one of the least reactive chemical elements (resistant to corrosion).
- Gold often occurs in free elemental (native) form, as nuggets or grains, in auriferous (rocks containing gold) rocks, in vein, and in alluvial deposits.

Gold Reserves and Production in India

- As of 2015, the total reserves of gold ore in the country have been estimated at 502 MT.
- The total reserves of gold (primary), in terms of metal stood at **655 Tons**.

India's Gold Ore reserves			India's Gold Production	
State	% Share	In terms of Metal Content	State	FY 2017-18
1. Bihar	44%	1. Karnataka	1. Karnataka	99%
2. Rajasthan	25%	2. Rajasthan	2. Jharkhand	1%
3. Karnataka	21%	3. Andhra Pradesh	The domestic production nowhere meets the domestic demand. The demand is mainly met through imports.	
4. West Bengal	3%	4. Bihar		
5. Andhra Pradesh	3%	5. Jharkhand		
6. Jharkhand	2%	Total: 655 Tons	Total	550 TT
Karnataka	<ul style="list-style-type: none"> Gold mines are located in Kolar (Kolar Gold Field), Dharwad, Hassan and Raichur (Hutti Gold Field) districts. Kolar Gold Fields is one of the deepest mines of the world. (Usually, gold mines are the deepest mines in the world. Mponeng Gold Mine in South Africa is one of the deepest mine in the world (3.9 km deep)). Hutti mines are exploited to their maximum levels and the ore left behind is of very low grade. The Kolar Gold Field has also run out of quality reserves and is on the verge of closure. 			
Jharkhand	<ul style="list-style-type: none"> Sands of the Subarnarekha (gold streak) river have some alluvial gold. Sona nadi in Singhbhum district is important. Sonapat valley is another major site with alluvial gold. 			
Andhra Pradesh	<ul style="list-style-type: none"> Ramagiri in Anantapur district is the most important gold field in AP 			
Kerala	<ul style="list-style-type: none"> The river terraces along the Punna Puzha and the Chabiyar Puzha have some alluvial gold. 			

World's Gold Reserves and Gold Production

World's Gold Reserves (in MT)	World's Production of Gold in MT
11,000	3,000

MT)		2017 (in TT)		
Country	Reserves	Country	Production	Major gold mines
1. Australia	9.8	1. China	426	13%
2. South Africa	6	2. Australia	294	9%
3. Russia	5.3	3. Russia	270	8%
4. USA	3	4. USA	237	7%
5. Peru	2.6	5. Canada	176	5%
6. Indonesia	2.5	6. Peru	151	5%
7. Brazil	2.4	7. Ghana	137	4%
8. Canada	2	8. South Africa	137	4%
9. China	2	9. Mexico	127	4%
World Total	54 MT	World Total	3.3 MT	

8.2 Silver

- Silver is grouped in the category of noble metals (**highly resistant to corrosion; e.g. gold, platinum, etc.**).
- Silver is known to have the **highest electrical and thermal conductivity** amongst all metals.
- It is used in printed electric circuits, coating (**electroplating**) for electronic conductors and in alloys of gold & copper for electrical contacts.
- Its chloride and iodide are light-sensitive and hence used in **photographic material**.
- Silver (in paste form) is used on **solar cells**.
- The chief ore minerals of silver are **stephanite, pyrargyrite and proustite**.

Silver Reserves and Production – India & World

- In India, there are no native silver deposits except the small **Bharak deposit in Rajasthan**.
- Silver occurs generally with lead, zinc, copper (especially their sulphide ore) and gold ores and

is extracted as a by-product from electrolysis or chemical methods.

- Silver was recovered in the past as a co-product in gold refining at KGF and Hutt Gold Mines in Karnataka.
- Silver is now recovered as a by-product from **Hindustan Zinc Smelter, Chanderiya, Chittorgarh** in Rajasthan, **Tundoo smelter in Jharkhand** and **Visakhapatnam smelter in AP** and from gold refinery of Hutt.
- The Hindustan Copper Ltd. at Maubhandar smelter in **Singhbhum district** of Jharkhand obtains silver from copper slimes.
- The total reserves of silver in India as of 2015 have been estimated at about 511.95 MT.
- The total reserves of silver in terms of metal were estimated at 29,982 tonnes.
- **Rajasthan** accounts for 87% reserves in terms of ore, Jharkhand 5%, Andhra Pradesh 3% and Karnataka 2%.
- Indian produced ~557.7 Tons of silver in 2017-18 of which **Rajasthan** alone accounted for ~557 tons. The rest came from Karnataka.

World's Silver Reserves (in TT)		World's Production of Silver in 2017 (in TT)		• India's Imports of silver increased to 5.9 TT in 2017-18 as compared to 3.4 TT in the preceding year. • The rise in imports is due to huge demand from Photovoltaics (PV) industry . • Imports were mainly from the Hong Kong (43%), UK (17%) , Russia (13%), China (10%).
Country	Reserves	Country	Production	
1. Peru	110	1. Mexico	5.8	
2. Poland	110	2. Peru	4.3	
3. Australia	89	3. China	3.5	
World Total	560	India	0.5 TT	

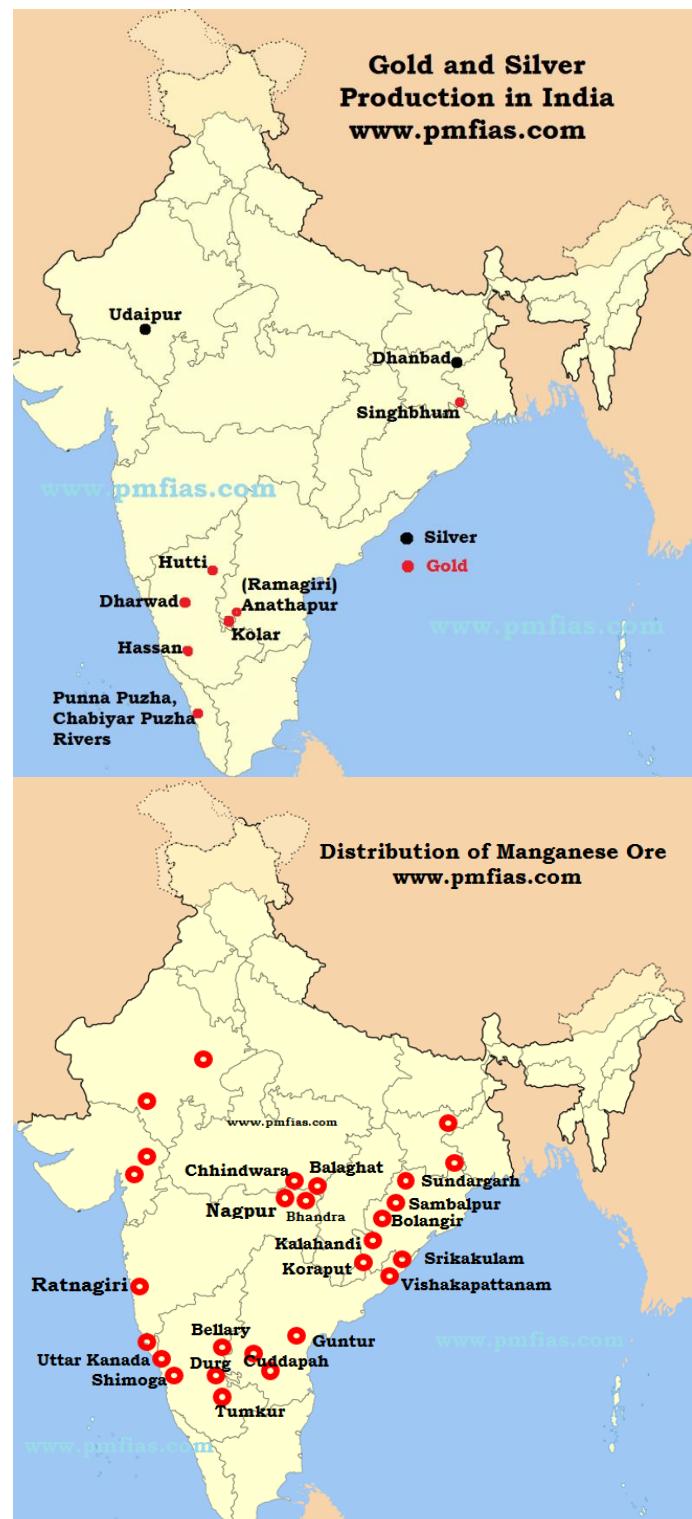
9. Ores of Metals used in Alloys

9.1 Manganese

- Manganese is very hard and brittle in nature.
- It is always available in combination with iron, laterite and other minerals.
- Manganese ores of major commercial importance are **pyrolusite**, psilomelane, manganese & braunite.
- Manganese is added to steel to increase its strength.
- Manganese in aluminium alloy cans improves the resistance to corrosion.
- Iron & Steel Industry is the major consumer of manganese ore wherein manganese ore is used directly as a blast furnace feed (manganese de-oxidizes and desulfurizes steel).
- Most of the manganese goes into the production of manganese alloys such as ferromanganese.

Manganese ore distribution in India

- Indian manganese ore deposits occur mainly as metamorphosed sedimentary deposits.
- Gondite deposits:** Madhya Pradesh (**Balaghat & Chhindwara** districts), Maharashtra (**Bhandara & Nagpur** districts), Gujarat (Panchmahal district) and Odisha (**Sundargarh district**).
- Kodurite & Khondolite deposits:** Odisha (**Koraput** district) and Andhra Pradesh (**Srikakulam** district).
- Presently India is one of the major importers of manganese ore in the world.
- Imports of manganese ore stood at 3.57 MT.
- South Africa (58%), Australia (14%) and Gabon (13%)** were the main suppliers of manganese ore in 2017-18.



India's Manganese Ore Reserves as of 2015 have been placed at 496 MT		India's Manganese Ore Production 2017-18 in TT	
State	% Share	State	Production
Odisha	44%	Madhya Pradesh	831
Karnataka	22%	Maharashtra	731

Madhya Pradesh	12%	Odisha	517
Maharashtra	7%	Karnataka	294
Goa	7%	Andhra Pradesh	167
Andhra Pradesh	4%	Total	2.6 MT

Manganese ore distribution across the World

World's Manganese Ore Reserves in MT		World's Manganese Ore Production in MT	
Country	Reserves	Country	Production
1. South Africa	230	1. South Africa	13.8
2. Ukraine	140	2. China	12.5
3. Brazil	110	3. Australia	6
4. Australia	99	4. Gabon	4
India	33	5. Ghana	3
World Total	760 MT	6. India	2.5

9.2 Tungsten

- **Tungsten (wolfram)** is a rare metal found naturally on Earth combined with other elements.
- It is a hard steel-grey shiny metal that is often **brittle and hard to work**.
- Its important ores include **wolframite** and **scheelite**.
- Tungsten has the **highest melting point (3422 °C)** among elements.
- It also has the **highest boiling point (5930 °C)**.
- Its density is comparable to that of uranium and gold, and **much higher than that of lead**.
- Much of the wolfram is used by the **steel industry** (it imparts **self-hardening** property to steel).
- It is elastic, ductile and has high tensile strength and can be drawn into very thin wires.

- Tungsten is easily alloyed with chromium, nickel, molybdenum, titanium, etc. to yield a number of hard facing, heat and **corrosion resistant alloys (resistant to all acids)**.
- Tungsten carbide is used in cemented carbides (hardmetals) which are wear-resistant materials used by the metalworking and mining industries.
- Tungsten's hardness and high density give it military applications in penetrating projectiles.
- Tungsten is also used to make heavy metal alloys for armaments, high-density applications, such as superalloys for turbine blades.
- Tungsten's many alloys have numerous applications, including incandescent **light bulb filaments, X-ray tubes, electrodes in gas tungsten arc welding**, superalloys, and radiation shielding.

Distribution of Wolfram in India and across the World

World's Tungsten Reserves (in MT)		World's Tungsten Production (in MT)		India's Tungsten Reserves		
Country	Reserves	Country	Production	State	Share	Regions
1. China	1900	1. China	65	Karnataka	42%	Kolar Gold Fields
2. Russia	240	2. Vietnam	6.4	Rajasthan	27%	Degana in Nagaur district
World Total	3300 MT	3. Russia	2	Andhra Pradesh	17%	East Godavari district
Indian has total reserves of 87.39 MT of tungsten				Maharashtra	9%	Sakoli basin in Nagpur district

- The domestic requirements of tungsten and its products are met mainly through imports from **China**, Austria, Korean Republic, etc.

9.3 Copper

- Copper is one of the few metals that **occurs in nature in directly** usable metallic form (native metals). Copper is a malleable and ductile metal with very high thermal and **electrical conductivity**.
- Copper and its alloys are widely used in electrical industry.
- Pure gold is 24 carat gold. This is alloyed with 2 parts of silver or copper to make it hard (22 carat gold).

Major Copper Alloys

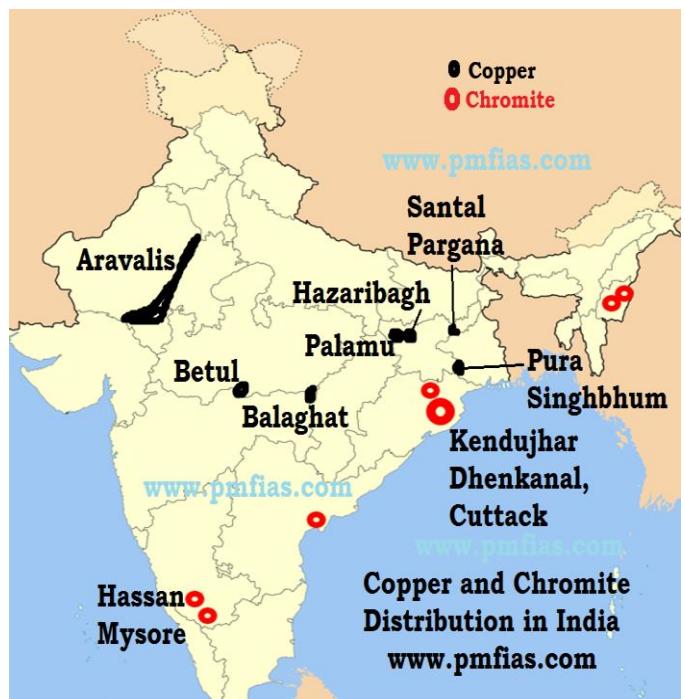
Iron + Nickel + Copper + Chromite + → Stainless Steel
Copper + Nickel → Morel Metal
Copper + Aluminium → Duralumin
Copper + Zinc → Brass
Copper + Tin → Bronze

Copper Ore Distribution and Production in India

- Hindustan Copper Limited (HCL), a PSU, is the only integrated company in the country that is

involved in mining & beneficiation of ore and is engaged in smelting, refining and casting of refined copper.

- The copper ores contain a small percentage of the metal and hence mining is expensive.
- The total reserves of copper ore in India as of 2015 are estimated at 1.51 billion tonnes.
- The total metal content out of the total resources is a mere 12.16 million tonnes (**low grade copper ore**).
- Hence India imports most of its copper.



Copper ore reserves in India				
State	Ore Reserves (MT)		Metal Reserves (MT)	Major districts with ore reserves
1. Rajasthan	813		54%	4.5
2. Jharkhand	295		19.5%	3.2
3. Madhya Pradesh	283		18.8%	3.4
Total	1.51 BT		12.1 MT	

Copper Ore and Coper Metal production in India in 2017-18		
State	Copper Ore Production (MT)	Copper Metal Production (TT)
Madhya Pradesh	2.3	20
Rajasthan	1.1	11.2
Jharkhand	0.18	1.5
Total	3.68 MT	33 TT

Distribution of Copper Ore and Production Across the World

- The world mine production of copper was at

20.2 million tonnes of metal content in 2017.

World's Copper Reserves in MT		World's Copper Production in MT	
Country	Reserves	Country	2017
1. Chile	170	Chile	5.5
2. Australia	88	Peru	2.4
3. Peru	83	China	1.7



[Image Source and Credits](#)

of fats and oils intended for use in soap and foodstuffs.



Distribution of Nickel in India and World

- Nickel occurs principally as oxides, sulphides and silicates in India.
- Important occurrence is in **Sukinda Valley, Jajpur district, Odisha**, where it occurs as oxide.
- Nickel also occurs in sulphide form along with copper in **East Singhbhum district, Jharkhand**.
- In addition, it is found associated with uranium deposits at **Jaduguda, Jharkhand**.

9.4 Nickel

- Nickel does not occur free in nature. It is found in association with copper, uranium and other metals.
- It has relatively low electrical conductivity, **high resistance to corrosion, excellent strength at high temperatures** and capable of getting magnetised.
- Hence nickel steel is used for manufacturing **armoured plates, bullet jackets** etc.
- Nickel is an important alloying material.

Iron + Nickel → Stainless Steel

Nickel + Copper or Silver → Rupee Coins

- Nickel-aluminium alloys are used for **manufacturing aeroplanes** and **internal combustion engines**.
- Metallic nickel is used for making batteries and as a catalyst for **hydrogenation or hardening**

- Other important occurrences of nickel are in Karnataka, Kerala and Rajasthan.
- Polymetallic sea nodules are another source of nickel.

India's Nickel Ore Reserves in MT		World's Nickel Metal Reserves in MT		World's Nickel Metal Production in 2017 in TT		Imports in 2016-17 in Tons	
State	Reserves	Country	Reserves	Country	Reserves	Country	Qty
1. Odisha	175	93%	Indonesia	21		1. Indonesia	339
2. Jharkhand	9	4.7%	Australia	19	2. Philippines	315	Australia
3. Nagaland	5	2.6%	Brazil	11			Total
Total	189 MT		World Total	89 MT	3. Russia	221	1062 T

9.5 Molybdenum

- Molybdenum is used as an **alloying agent in steel, cast iron**, nickel, cobalt, titanium & **superalloys** to enhance strength and resistivity to wear & corrosion.
- As a refractory metal, it is used in many electrical and electronic components.
- Molybdenum plays a vital role in the energy industry and it may become essential in **green technology**.

- Molybdenum **does not occur freely** in nature.
- Molybdenite** is the principal ore of molybdenum.
- In India, molybdenum **is associated generally with copper, lead and zinc ores**.
- In India, molybdenum is produced intermittently from uranium ore of **Jaduguda mine** in Jharkhand.
- There are several **critical minerals** that India lacks and one of them is molybdenum.

India's Molybdenum Reserves in MT		World's Molybdenum Reserves in MT		World's Molybdenum Production in 2017 in TT	
State	Reserves	Country	Reserves	Country	Production
1. Tamil Nadu	10	1. China	8300	1. China	130
2. Madhya Pradesh	8	2. USA	2700	2. Chile	62
3. Karnataka	1.32	3. Peru	2400	3. USA	44
Total	19.4 MT	World Total	17000	4. Peru	28

molybdenum, copper, titanium, zirconium, vanadium, selenium, etc.

Chromite Distribution across India and World

- The total reserves of chromite in India as of 2015 is estimated at 344 MT.
- More than 96% resources of chromite are located in **Odisha (Jajpur, Kendujhar and Dhenkanal districts)**.
- Minor deposits are scattered over **Manipur, Nagaland, Karnataka**, etc.
- The production of chromite was 3.4 MT during 2017. **Odisha** alone produced 3.3 MT (rest from Karnataka).
- Imports of chrome ore were mainly from South Africa (99%).

9.6 Chromite

- Chromite (iron chromium oxide)** is the commercially viable ore of **chromium**.
- The chromium extracted from chromite is used in **chrome plating** and alloying for production of **corrosion resistant** super alloys, nichrome, and **stainless steel**.
- It is also used in the manufacture of alloys along with other metals, such as nickel, cobalt,

World's Chromium Metal Reserves in MT		World's Chromite Production in MT	
Country	Reserves	Country	2017
1. Kazakhstan	230	1. South Africa	16.5
2. South Africa	200	2. Turkey	6.6
3. India	100	3. Kazakhstan	6.3
World Total	560	4. India	3.4

9.7 Cobalt

- Cobalt is an important **ferromagnetic alloying metal** having irreplaceable industrial applications.
- Cobalt is extracted as a by-product of copper, nickel, zinc or precious metals.
- Major use of cobalt is in metallurgical applications, in special alloy/super alloy industry.
- Super alloys** made of cobalt are wear & corrosion-resistant at elevated temperatures.

- Hard-facing or cutting tools with cobalt alloys provide greater resistance to wear, heat, and corrosion.
- Cobalt is used as precursors (cobalt compounds) for **cathodes in rechargeable batteries**.
- Largest demand for cobalt has been from the **Rechargeable Battery Industry (Lithium ion battery)**.
- Cobalt is alloyed with aluminium and nickel to manufacture powerful magnets.

Distribution of Cobalt Reserves across India and the World

State	Reserves in MT		Region with reserves
1. Odisha	31	69%	Kendujhar and Jajpur districts
2. Jharkhand	9	20%	Singhbhum district
3. Nagaland	5	11%	Tuensang district
Total	44.9 MT		Presently, there is no production of cobalt from primary cobalt resources.

- India is aggressively pushing electric mobility. All electric vehicles at present use **Lithium ion batteries**.
- Hence, India has to aggressively push to secure **lithium and cobalt (strategic minerals)** resources both internally and externally.
- China has already taken a substantial lead in the race by aggressively procuring these minerals from **Congo**.
- The demand for cobalt is usually met through imports.
- Recycling technologies** for recovery of cobalt from **waste Li-ion batteries** have been an evolving process.
- Imports of cobalt and alloys were at 875 tonnes in 2017-18.
- Imports were mainly from USA & Canada (13% each), Belgium (12%), Norway & UK (9% each) and China (8%) & Morocco (7%).

World's Reserves of Cobalt Content (in TT)			World's Production of Cobalt Content in 2017 (in TT)		
Country	Reserves		Country	Production	
Congo (Kinshasa)	3400	49%	Congo	82.5	59%
Australia	1200	17%	New Caledonia	9.4	7%
Cuba	500	7%	China	9	6%
Philippines	280	4%	Canada	6.5	5%
Canada	250	4%	Australia	5.2	4%
World Total	6900 TT		Total	139 TT	

10. Strategic Minerals

10.1 Lithium

It's used in the manufacture of aircraft and in certain batteries.

- Lithium is lightest known metal. It has a density of 0.534 g/cm³ (half as dense as water).
- It's light and soft and has lowest melting points of all metals and a high boiling point.
- Lithium-ion batteries** are key to lightweight, rechargeable power for laptops, phones, electric vehicles, etc.

- Lithium** and another battery component, **cobalt**, could become scarce as demand increases
- Lithium is highly reactive and flammable and must be stored in mineral oil.
- It never occurs freely in nature, but only in compounds such as igneous rocks formed underground.
- China controls most of the lithium supply across the world.

World's Lithium Reserves in MT			World's Lithium Production in TT		
Country	Reserves		Country	Production	
Chile	7.5	47%	Australia	18.7	43%
China	3.2	20%	Chile	14.1	33%
Australia	2.7	17%	Argentina	5.5	13%
Argentina	2	13%	China	3	7%
World total	16 MT		World total	43 TT	

KABIL Set up to Ensure Supply of Critical Minerals

PIB | 01-08-2019

- A joint venture company namely **Khanij Bidesh India Ltd. (KABIL)** is to be set up with the participation of three Central Public Sector Enterprises namely,
 - ✓ **National Aluminium Company Ltd. (NALCO)**,
 - ✓ **Hindustan Copper Ltd. (HCL)** and
 - ✓ **Mineral Exploration Company Ltd. (MECL)**.
- The equity participation between NALCO, HCL and MECL is in the ratio of 40:30:30.
- Objective of constituting KABIL is to ensure a consistent supply of **critical and strategic minerals** to Indian domestic market.

KABIL functions

- The KABIL would carry out identification, exploration, development, mining and processing of

strategic minerals **overseas** for commercial use and meeting country's requirement of these minerals.

- The new company will help in building partnerships with other mineral rich countries like Australia and those in Africa and South America.

The Need for KABIL

- Indian is betting big on Electric Vehicle Mobility therefore it is important to ensure energy storage through batteries.
- Aviation, Defence and Space Research also require minerals with lower weight and high mechanical strength.
- Among such twelve minerals identified as strategic minerals, which have meagre resource base, **Lithium** and **Cobalt** are significant.

There are more strategic minerals that are scarce but are indispensable for India. They will be covered under "current affairs" whenever they are in news

11. Non Metallic: Graphite and Diamond

11.1 Graphite

- Graphite, also known as **plumbago** or **black lead**, is the most stable form of carbon.
- It is extremely soft (greasy feel), cleaves (splits into layers) with very light pressure.
- It is extremely resistant to heat and is highly unreactive.
- Graphite is the only non-metal that can conduct electricity.**
- The carbon content in Graphite is high (more than that in anthracite coal).
- Graphite may be considered the highest grade of coal, just above anthracite.

Carbon content in **Peat < Lignite < Bituminous < Anthracite < Graphite < Diamond**

- It is not normally used as fuel because it is difficult to ignite.
- Most of the graphite is formed at **convergent plate boundaries** where organic-rich shales and limestones were subjected to **metamorphism** due to heat and pressure.

Distribution of Graphite across India and World

Total resources of Graphite in India in MT			Total recoverable resources of Graphite in India in MT				
State	Resources		State	Recoverable Resources			
1. Arunachal Pradesh	72	37%	1. Jharkhand	4.2	52%		
2. Jammu & Kashmir	62	32%	2. Tamil Nadu	3.4	42%		
3. Odisha	19	9.7%	3. Odisha	0.5	6%		
4. Jharkhand	17	9%	Total	8 MT			
5. Tamil Nadu	7.9	4%	<ul style="list-style-type: none"> Production of graphite at about 33.5 TT in 2017-18 Jharkhand (19 TT – 56%) was the leading producer, followed by Odisha and Kerala. 				
6. Madhya Pradesh	5.7	2.9%					
Total	195 MT						

- Graphite mines, barring a few underground mines are mostly small and opencast.
- Active mining centres of graphite are in **Palamu district in Jharkhand; Nuapada & Balangir districts in Odisha; and Madurai & Sivaganga districts in Tamil Nadu.**

World's Graphite (natural) Reserves in MT		World's Graphite (natural) Production in TT		<ul style="list-style-type: none"> India's imports of graphite (natural) in 2017-18 were 40 TT. Graphite (natural) was imported from China (86%), Brazil (6%). Imports of Graphite (artificial) in 2017-18 were 67 TT. Imports of graphite (artificial) were from China (48%), Poland (17%), Malaysia (16%).
Country	Reserves	Country	Production	
1. Turkey	90	1. China	900 (88%)	
2. China	73	2. Brazil	82 (8%)	
3. Brazil	72	3. India	34 (3%)	
India	8	4. Canada	30	
World Total	300	Total	1 MT	

11.2 Diamonds

- Diamond is the hardest naturally occurring substance found on Earth. Its composition is **pure carbon**.
- Diamonds are formed in mantle (formed from carbon under very high temperatures and pressures).
- They are brought to the earth's crust due to **volcanism**.

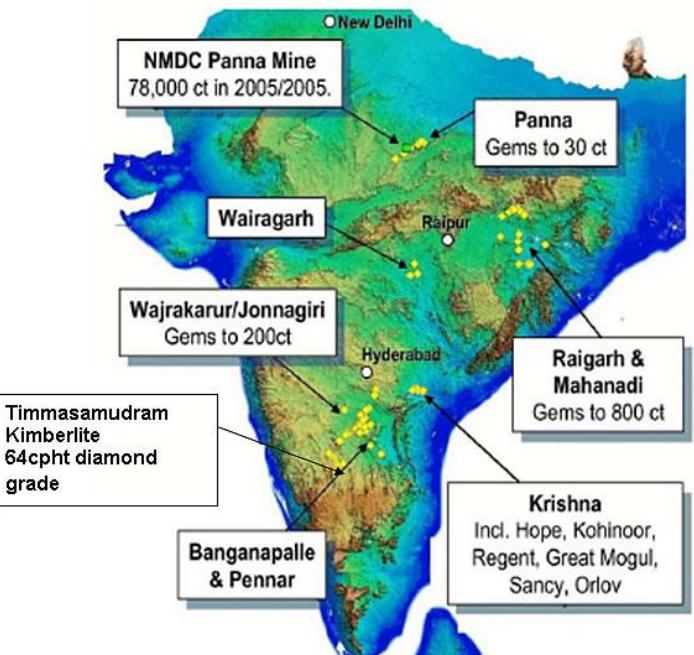
Synthetic diamonds compete as an abrasive mineral with natural industrial diamonds.

Distribution of Diamond Bearing rocks and gravels in India

- Andhra Pradesh: **Anantapur (Wajrakarur Kimberlite pipe)**, Kadapa, Guntur districts;
- Madhya Pradesh: **Panna belt**;
- Chhattisgarh: Raipur and Bastar districts; and
- Odisha: region lying between Mahanadi and Godavari valleys.
- The new kimberlite fields were discovered in Raichur-Gulbarga districts of Karnataka.

India's Diamond Reserves in Million Carats			India's Diamond Production in 2017 in Thousand Carats	
State	Reserves		State	Production
1. Madhya Pradesh	28.7	90%	Madhya Pradesh	39.7
2. Andhra Pradesh	1.8	5.7%	100% of India's Diamond Production happens in Majhgawan, Satna District, Madhya Pradesh .	
3. Chhattisgarh	1.3	4%		
Total	31.83 million carats			

- India depends almost entirely on imports of rough gem diamonds for its Cutting and Polishing Industry.
- Workmanship of Indian artisans at polishing small diamonds economically has been widely acknowledged.
- Most of the world's diamond cutting and polishing is done in **Surat, Gujarat**.
- In 2017-18, imports value of diamonds was 1,90,203 crores.
- Imports were mainly from Unspecified countries! (27%), UAE (15%), Belgium (14%), Russia (12%), etc.
- Value of diamond exports stood at 1,62,022 crores in 2017-18.
- Exports were mainly to Hong Kong (40%), USA (30%), Belgium (9%), etc.



Diamonds Across the World

World's Diamond Reserves in Million Carats		World's Diamond Production in Million Carats	
Country	Reserves	Country	Production
1. Russia	650	1. Russia	42.6
2. Congo	150	2. Botswana	22.9
3. Australia	120	3. Canada	22.7
4. Botswana	90	4. Australia	17.1
5. South Africa	70	5. Congo	15.4
World Total	1200	6. South Africa	9.7



- **Botswana is the leading diamond-producing country** in terms of value, and the second largest in terms of volume. The two important ones are **Orapa** and **Jwaneng**.
- Australia is famous for its pink, purple and red diamonds.
- **Kimberley Diamond Mine** in South Africa is well known.

- Graphite & Diamond are the major **allotropes of carbon**. Other important allotrope being **anthracite coal**.

Allotrope: two or more different physical forms in which an element can exist (e.g. graphite, charcoal, and diamond as forms of carbon).

- Graphite and diamond share the same composition but have very different structures.

Differences Between Graphite and Diamond

Graphite	Diamond
<ul style="list-style-type: none"> • Pure graphite contains 95-99% carbon. • Graphite is a non-metallic mineral that forms when carbon is subjected to extreme heat and pressure in Earth's crust and in the upper mantle. • Graphite is one of the most stable substances on earth. • The carbon atoms in graphite are linked in a hexagonal network that forms sheets that are one atom thick. • These sheets are poorly connected and easily cleave or slide over one another if subjected to a small amount of force. • This gives graphite its very low hardness, its perfect cleavage and its slippery feel (E.g. Pencil lead). 	<ul style="list-style-type: none"> • Diamond is 100% carbon. • Diamond is also a non-metallic mineral that forms when carbon is subjected to extreme heat and pressure in the mantle. • Diamond (one of the most stable) is less stable than graphite. • In contrast, the carbon atoms in diamond are linked into a frameworks structure. • Every carbon atom is linked into a three dimensional network with strong covalent bonds. • This arrangement holds the atoms firmly in place and make diamond an exceptionally hard material.

12. Non Metallic: Limestone, Dolomite and Magnesite

12.1 Limestone

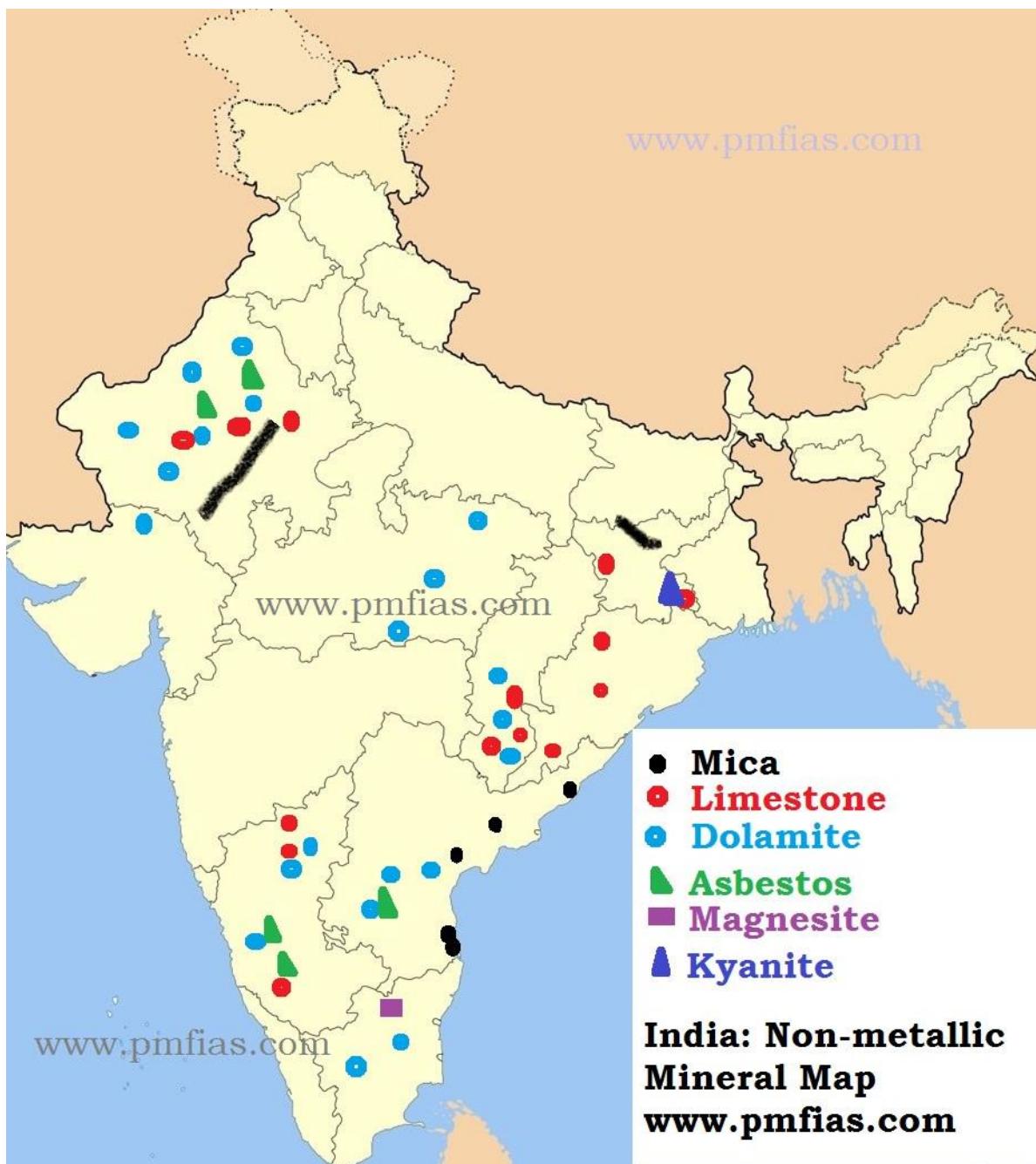
- Limestone is sedimentary rock composed mainly of **calcium carbonate** (CaCO_3).

- The most important constituents of limestone are **calcite**, **magnesite** (**magnesium carbonate**) and **dolomite** (**calcium magnesium carbonate**).

- The dolomitic limestone in Gujarat is used for making slabs and tiles.
- Limestone of Kalburgi district, commonly known as 'Shahabad stones' are used as flooring stones.
- Pulverised limestone is used as a soil conditioner to neutralise acidic soils (agricultural lime).
- 75 per cent Limestone is used in **cement industry**, 16 per cent in **iron and steel industry** and 4 per cent in the chemical industries.

- In **blast furnaces**, limestone (flux) binds with silica and other impurities and facilitates their removal.
- As a reagent in fuel-gas desulphurisation, it reacts with sulphur dioxide which enables air pollution control.
- It can suppress methane explosions in underground coal mines.

Distribution of Limestone in India



- Almost all the states of India produce some quantity of limestone.

India's Limestone Reserves in BT			India's Production of Limestone (2017-18) in MT		
State	Reserves	State	Production	Regions	
1. Karnataka	55 27%	1. Rajasthan	75 22%	Almost all districts	
2. Andhra Pradesh	24 12%	2. Madhya Pradesh	44 13%	Jabalpur, Satna, Betul	
3. Rajasthan	24 12%	3. Andhra Pradesh	37 11%	Kurnool, Guntur	
4. Gujarat	20 10%	4. Chhattisgarh	37 11%	Bastar, Durg, Raipur	
5. Meghalaya	18 9%	5. Karnataka	31 9%	Kalburgi, Shimoga	
Total	203 BT	Total	340 MT		

- Exports of limestone in 2017-18 was 2.81 MT.
- Limestone in bulk was exported mainly to Bangladesh (95%) and UK (2%) on the other hand.
- Imports of limestone in 2017-18 was 20.83 MT.
- Limestone was imported mainly from **UAE (78%)**, Oman (13%), Vietnam (4%).
- Rest of the limestone is used in paper, sugar, fertilizers, etc.

- Dolomite is used as blast furnace flux, as a source of magnesium salts and in fertilizer and glass industries.
- Iron and Steel industry is the chief consumer of dolomite (90 per cent) followed by fertilizer.
- Dolomite is widely distributed in the all parts of the country.
- Orissa, Chhattisgarh, Andhra Pradesh, Jharkhand, Rajasthan and Karnataka are the main producing states and contribute more than 90 per cent of the total production.
- Orissa** and **Chhattisgarh** together account for about 57 per cent dolomite of India.
- Dolomite rock (Dolomitic Limestone) contains calcium magnesium carbonate.
- Dolomite occurrences are widespread in almost all parts of the country.

State	Reserves	Production	Major Districts
Madhya Pradesh	27%	Orissa (29%)	Sundargarh, Sambalpur and Koraput districts
Andhra Pradesh	15%	Chhattisgarh (28%)	Bastar, Bilaspur, Durg and Raigarh districts
Chhattisgarh	11%	Jharkhand	Singhbhum district and Palamu district
Odisha	10%	Rajasthan	Ajmer, Alwar, Bhilwara, Jaipur, Jaisalmer district
Total	8.4 BT	Karnataka	Belgaum, Bijapur districts

- India exported 1.9 MT of dolomite in 2015-16.
- Exports were mainly to Nepal (86%) and Bangladesh (11%).

- It is also used as a bond in abrasives, manufacture of cement for tiles and for extraction of the magnesium.
- India has 394 MT of magnesite reserves; Uttarakhand (59%), Tamil Nadu (25%) and Rajasthan (14%).
- Tamil Nadu has one of the largest deposits of magnesite in the world and the largest in India are found at **Chalk Hills** near Salem town.
- Tamil Nadu (69%) continued to be the major producing state followed by Uttarakhand and Karnataka.
- India imported 229 TT of magnesite in 2017-18 from **China** (33%), Pakistan (19%), Turkey (16%).

12.3 Magnesite

- Magnesite ($MgCO_3$) is a carbonate of magnesium.
- The Refractory Industry is the major consumer of magnesite.
- It is primarily used for manufacturing refractory bricks.

13. Other Non-Metallic Mineral Resources

13.1 Mica

- Mica is a naturally occurring non-metallic mineral that is based on a collection of **silicates**.
- Mica can be easily and accurately split into very thin sheets or films of any specified thickness.

- It has a unique combination of elasticity, toughness, flexibility and transparency.
- Mica is a very good insulator that has a wide range of applications in electrical and electronics industry.
- It possesses resistance to sudden change in temperature and can withstand high voltage.

Total resources of Mica in India in MT		Total Mica Production in India in Tons	
State	Reserves (2015)	State	Production 2014-15
Andhra Pradesh	41%	Andhra Pradesh (Gudur mines, Nellore)	636 (100%)
Rajasthan	21%		
Odisha	20%		
Maharashtra	15%		
Total	110 TT		

- In 2014-15, exports were mainly to China (63%), Saudi Arabia (6%).

13.2 Asbestos

- Asbestos is a group of six naturally occurring fibrous silicate minerals.
- The physical properties such as flexibility, tensile strength, high **resistance to electricity, fire and corrosion by acids**, make asbestos commercially important.
- Commercial asbestos is classified into two main mineralogical groups: **chrysotile (serpentine) asbestos** and **amphibole asbestos**.
- Commercially, chrysotile asbestos is far superior in physical properties.
- It is widely used for making **fire-proof** cloth, rope, etc.
- Asbestos cement products like sheets, pipes and tiles are used for building purposes.
- As of 2015, total reserves of asbestos in India were 23 MT.
- Rajasthan (59% – Ajmer, Udaipur, Bhilwara) and Karnataka (36% – Chikkamagaluru, Hassan, Mandya)** have the highest reserves.
- Russia, China, and Brazil** have 99% of the asbestos reserves.
- India's imports of asbestos were mainly from **Russia** (63%), Brazil (21%) and Kazakhstan (16%).

- India has enjoyed the monopoly in the production and export of sheet mica in the world.
- Of late, there has been a steady downfall in the production of mica due to artificial mica substitutes.

13.3 Kyanite

- Kyanite occurs in metamorphic aluminous rocks.
- It is primarily used in metallurgical, ceramic, refractory, glass, cement industries due to its **ability to stand high temperatures**.
- It is also used in making **sparkling plugs** in automobiles.
- India has the largest deposits of kyanite** in the world.
- Kyanite grades depend on aluminium content. Greater the aluminium content, greater the quality.
- Jharkhand, Maharashtra and Karnataka produce practically the whole of kyanite of India.
- Jharkhand (Singhbhum district) is the largest producer of kyanite (four-fifths).
- Maharashtra (second highest producer of kyanite). Most of the reserves are in Bhandara district.
- Karnataka is the third largest producer. Commercially, workable deposits occur in Hassan district.

Sillimanite

- The occurrence and uses of sillimanite are almost the same as those of kyanite.

- The main concentration of Sillimanite is found in Tamil Nadu, Orissa, Kerala, Andhra Pradesh.
- Orissa is the largest producer of sillimanite in India. Ganjam is an important sillimanite producing district.
- Kerala is the second largest producing state.

13.4 Gypsum

- Gypsum is a **hydrated sulphate of calcium**.
- It is a white opaque or transparent mineral.
- It occurs in sedimentary formations such as limestones, sandstones and shales.

- It is mainly used in making **ammonia sulphate fertilizer** and in **cement industry**.
- It makes upto 4-5 per cent of cement.
- It is applied in agriculture for conserving moisture in the soil and for aiding nitrogen absorption.
- Rajasthan** is by far the largest producer of gypsum in India (99 per cent of the total production of India).
- The main deposits occur in Jodhpur, Nagaur and Bikaner.
- The remaining gypsum is produced by Tamil Nadu (Tiruchirapalli district), Jammu and Kashmir.

14. Atomic Minerals

- Uranium, Plutonium** and **Thorium** are the main atomic minerals.
- Other atomic minerals are **beryllium, lithium and zirconium**.
- Zirconium is found along the Kerala coast & in alluvial rocks of Ranchi & Hazaribagh districts of Jharkhand.
- India has sufficient reserves of beryllium to meet her requirement of atomic power generation.

- Plutonium has occurred naturally, but except for trace quantities it is now not found in the Earth's crust.
- Plutonium is formed **in nuclear power reactors** from **uranium-238** by neutron capture.
- The most common plutonium isotope formed in a typical nuclear reactor is the fissile Pu-239.
- Pu-239 is the principal fuel in a **fast neutron reactor**.

14.1 Uranium

- Uranium is a silvery-grey metallic radioactive chemical element.
- It is only naturally formed in supernova explosions.
- Uranium, thorium, and potassium** are the main elements contributing to natural terrestrial radioactivity.
- Uranium has the chemical symbol U and atomic number 92.

- Uranium isotopes in natural uranium are **^{238}U (99.27%)** and **^{235}U (0.72%)**.
- All uranium isotopes are **radioactive and fissionable**.
- But only **^{235}U is fissile** (will support a **neutron-mediated chain reaction**).
- Traces of Uranium are found everywhere.
- Commercial extraction is possible only in locations where the proportion of Uranium is adequate.

Uranium Reserves and Production across the World

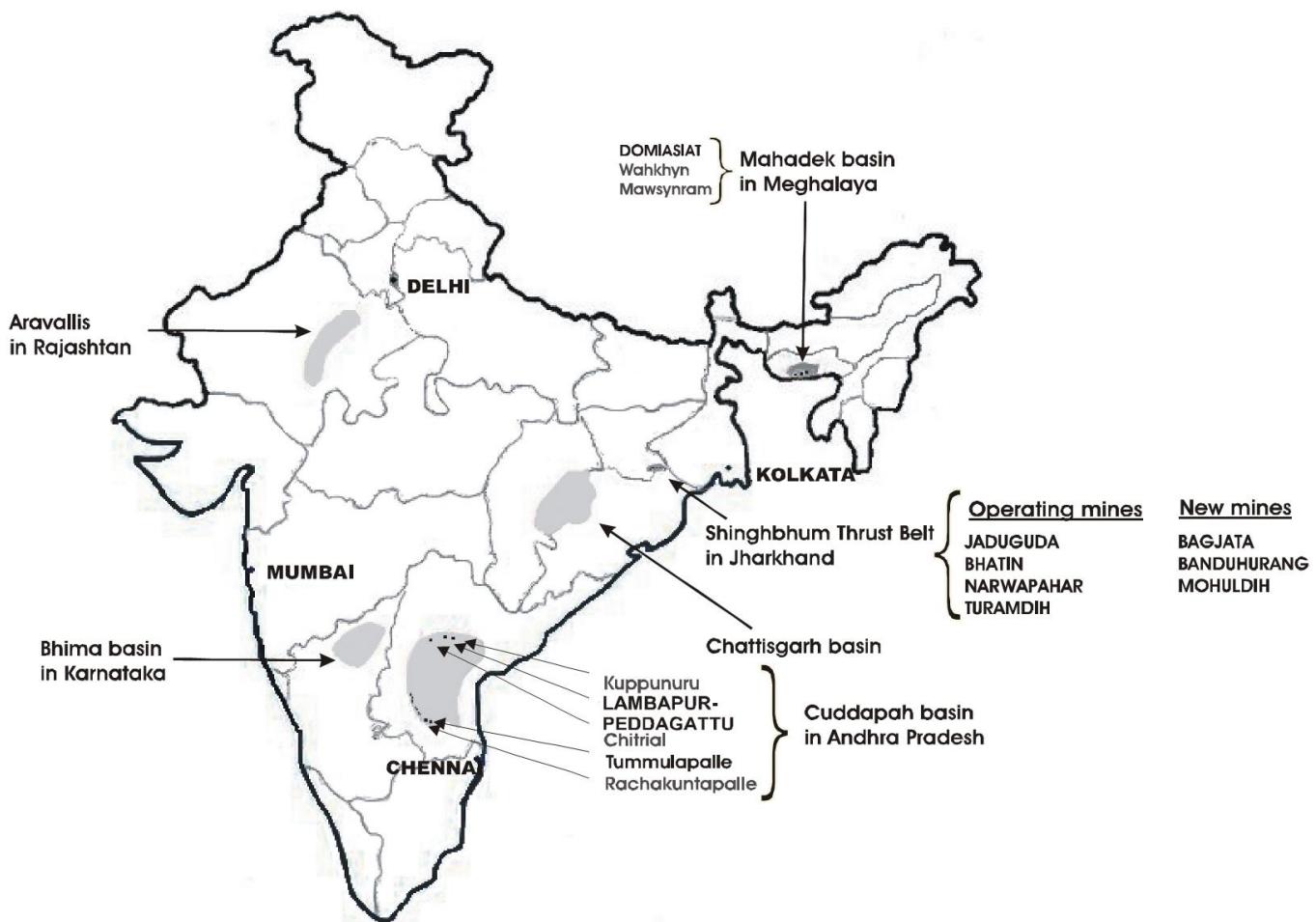
World's Uranium (U) Reserves (TT)			World's Uranium (U) Production (TT) in 2017		
Country	Reserves as of 2015		Country/Region	Production	
1. Australia	1780	23%	1. Kazakhstan	23.3	39.2%
2. Kazakhstan	941	12%	2. Canada	13.1	22.1%

3. Canada	703	9%	3. Australia	5.8	9.9%
4. Namibia	463	6%	4. Namibia	4.2	7.1%
India	139	2%	India	0.4	0.7%
Total	7641 TT		World	59 TT	

- **Olympic Dam** and the **Ranger mine** in Southern Australia are important mines in Australia.
- High-grade deposits are only found in the **Athabasca Basin** region of Canada.
- The **Chu-Sarysu basin** in central Kazakhstan alone accounts for most of the country's uranium resources

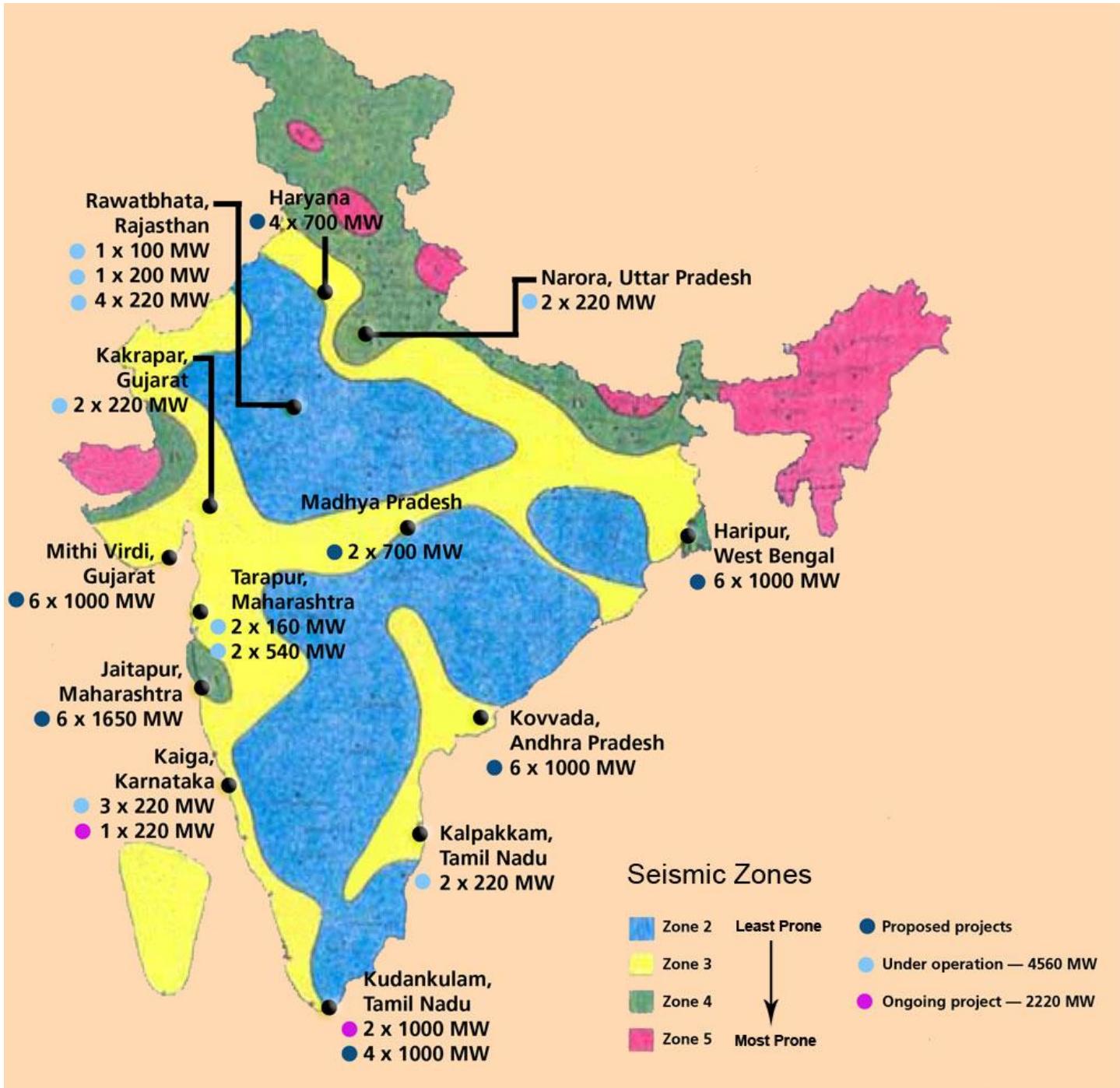
Uranium in India

- **Monazite sands** comprises the largest source of uranium.
- Monazite sands occur on **east and west coasts** and in some places in Bihar.



- But the largest concentration of monazite sand is on the **Kerala coast**.
- Over 15,200 tonnes of uranium is estimated to be contained in monazite.
- Some uranium is found in the copper mines of Udaipur in Rajasthan.
- Uranium deposits occur in **Jaduguda in Singhbhum Thrust Belt** and **Hazaribagh districts of Jharkhand**, **Gaya district of Bihar**, **Cuddapah basin of Andhra Pradesh**, **Aravallis**, & **Mahadek basin of Meghalaya**.

- Singhbhum Copper belt is known for a number of copper deposits with associated nickel, molybdenum, bismuth, gold, silver etc.
- The state of **Andhra Pradesh** is the largest producer of uranium in India.
- Tummalapalle village located in the **Kadapa (Cuddapah) district of Andhra Pradesh** is considered as one of the largest uranium reserves in India.



- India has no significant reserves of Uranium. All needs are met through imports.
- India imports thousands of tonnes of uranium from **Russia, Kazakhstan, France, and Uzbekistan**.
- India is trying hard to import uranium from Australia and Canada.
- However, there are some concerns regarding nuclear proliferation and other related issues.

14.2 Thorium

- Thorium is a chemical element with symbol Th and atomic number 90.
- Uranium and thorium** are the only radioactive elements that occur **naturally** in large quantities.
- Thorium is **weakly radioactive**: all its known isotopes are **unstable**, with the seven naturally

occurring ones (thorium-227, 228, 229, 230, 231, 232, and 234).

- **Thorium-232** is the most stable isotope of thorium and accounts for nearly all natural thorium, with the other five natural isotopes occurring only in traces.

- The other mineral carrying thorium is **thoria-nite**.
- Thorium is predicted to be able to replace uranium as nuclear fuel in nuclear reactors, but only a few thorium reactors have yet been completed.
- The known reserves of thorium in India are estimated to be between 457,000 and 508,000 tonnes.
- **Kerala, Jharkhand, Bihar, Tamil Nadu and Rajasthan** are the main producers.
- **United States, Australia, and India** have particularly large reserves of thorium.

Thorium Distribution

- Thorium is estimated to be about **three to four times more abundant than uranium** in the Earth's crust and is chiefly refined from **monazite sands**.
- Monazite contains 2.5% thorium **and is scattered along the Kerala Coast**.

World's Thorium Reserves (2011)		India's Thorium Reserves (2016)		
Country	Reserves in TT	State	Reserves	
1. India	963	1. Andhra Pradesh	31%	
2. United States	440	2. Tamil Nadu	21%	
3. Australia	300	3. Odisha	20%	
4. Canada	100	4. Kerala	16%	
5. South Africa	35	5. West Bengal	10%	

Related topics:

- [Nuclear Fission, Components of Nuclear Reactor, Types of Nuclear Reactors](#)
- [India's Three-Stage Nuclear Power Programme](#)