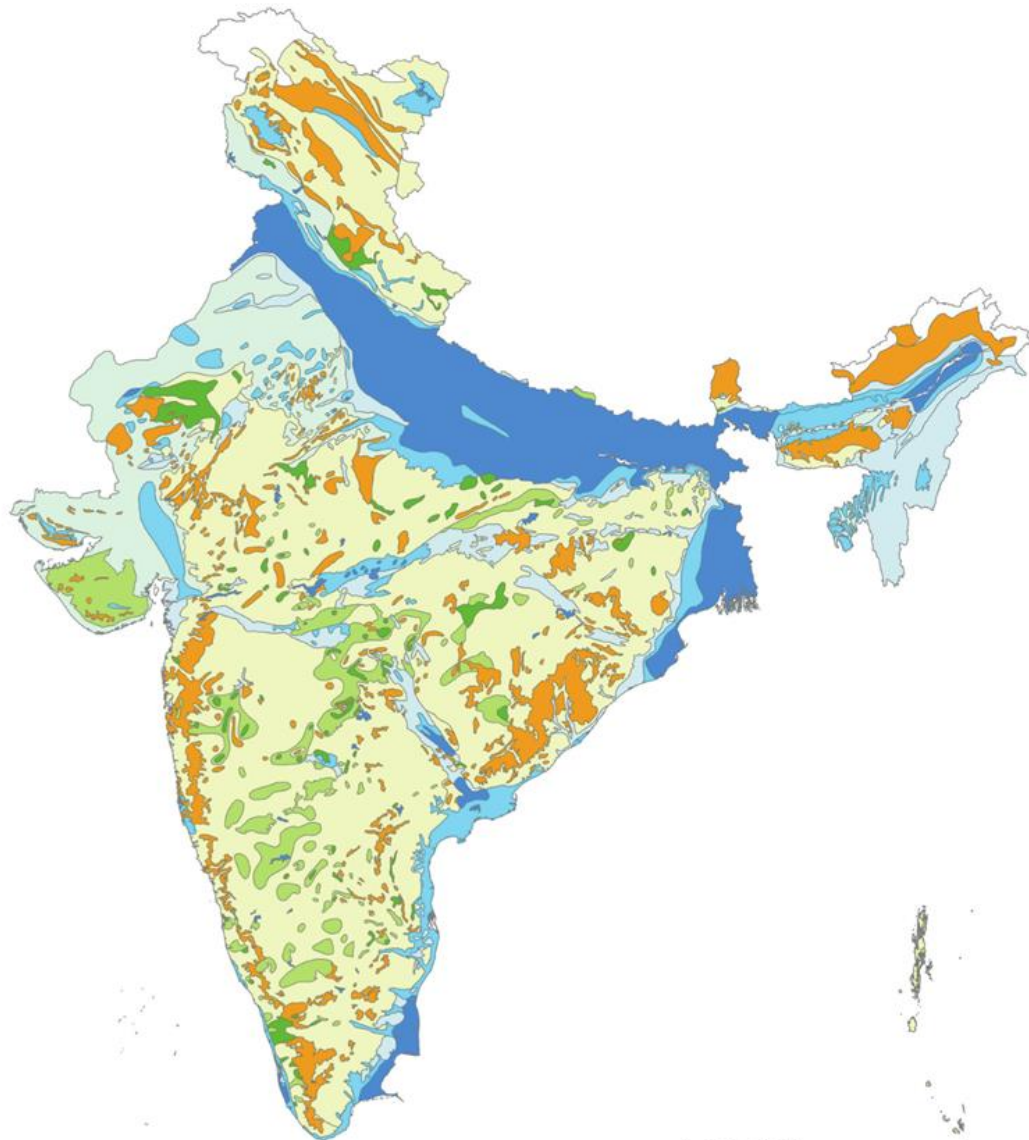


ADVANCED HYDROGEOLOGY
{MGELEC-1, M.Sc. Semester – IV}

GROUND WATER PROVINCES OF INDIA

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Hydrogeological Map of India



Legend

Ground Water Potential (Yield Litres/sec)

>40 25-40 10-25 <10

Unconsolidated Formations

1-25 1-10 1-5

Consolidated /Semi-Consolidated Formations

<1

Hilly Areas

HYDROGEOLOGICAL UNITS OF INDIA

Geological Age	Rock Formations	States / Hydrogeological Characters	
UNCONSOLIDATED FORMATIONS			
Pleistocene to Recent	a) Fluvio-glacial deposits b) Glacio-Lacustrine deposits	a) Mixed Boulders, Cobbles, Sands and Silts. b) Conglomerates, Sand, Gravels, Carbonaceous, Shales and Blue Clays	<ul style="list-style-type: none"> • The moraine deposits occupy valleys and gorges in interior Himalayas. • Karewas (Kashmir Valley) are lacustrine deposits displaying cyclic layers of clay, silt and coarse deposits with intervening boulder beds. • Locally forms significant hydrogeological potential.
	c) Piedmont and Himalayan Foot Hill deposits.	c) Boulders, Cobbles, Pebble Beds, Gravels, Sands, Silt and Clays	<ul style="list-style-type: none"> • The Bhabhar piedmont belt contains many productive boulders, cobble, gravel and sand aquifers. • The water table is deep. Forms recharge zone for deeper aquifer of alluvial plains in south. • Tarai belt is down slope continuation of Bhabhar aquifers. • The deeper confined aquifer display flowing artesian conditions.
	d) Alluvial Plains (Older & Newer Alluvium)	d) Clay, silt, Gravel and Sand layers e) Lenses of Peat and Organic matters, Carbonate and Siliceous Concretions (Kankar).	<ul style="list-style-type: none"> • Occur extensively in the Indo-Gangetic-Brahmaputra alluvial plain and forms prolific aquifers. • The potentials of peninsular rivers alluvium are rather moderate. But the alluvial valley fill deposits of Narmada, Tapi, Purna basins, are 100 m thick and sustain good yield.

	e) Aeolian Deposits (Sandstones)	f) Very fine to fine Sand and Silt.	<ul style="list-style-type: none"> • Multi-layer aquifers of North Gujarat are moderate to high potential aquifers. • The quality of ground water at deeper level is inferior. • Thick alluvial sequences in deltas of major rivers on the eastern coast and in Gujarat estuarine tracts. • Hydrogeological potential is limited due to the pevalent salinity hazards. <p>The Aeolian deposits occurring in major parts if the Rajasthan, Gujarat, Haryana, Delhi, Punjab have moderate to high yield potentials; are well sorted and permeable; lie in arid region; natural recharge is poor and water table is deep.</p>
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SEMI-CONSOLIDATED FORMATIONS

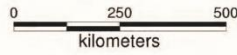
Tertiary		a) Nummulitic shales and Limestone b) Carbonaceous Shale, Sandstones, Shales, Conglomerates c) Ferruginous Sandstones d) Pebble Beds and Boulder, Conglomerate, Sands, Clays	<ul style="list-style-type: none"> • The Hydrogeological potential of these formations is relevant only in the valley areas. • Lower Siwaliks and their equivalents in Himachal Pradesh, Jammu & Kashmir, Assam, Punjab, Haryana, Uttar Pradesh, Sikkim generally do not form potential aquifers. • The Upper Siwaliks have moderate ground water potential specially in suitable topographic locations. • Tertiary sandstones of Rajasthan, Gujarat, Kutch, Kerala, Orissa, Tami Nadu, Andhra Pradesh, West
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			Bengal and North Eastern States have moderate to good yield potentials.
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Geological Age		Rock Formations	States / Hydrogeological Characters
Upper Carboniferous to Jurassic	a) Gondwanas b) Jurassic of Kutch and Rajasthan c) Bagh beds, Lameta formations and Equivalents	a) Boulder-Pebble beds b) Sandstones, Shales Coal Seams c) Sandstone, Calcareous Sandstone, Shale, Quartzites d) Limestone	<ul style="list-style-type: none"> • Occur in Jharkhand, Maharashtra, Andhra Pradesh, Orissa, Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan and Tamil Nadu • These formations do not have wide regional distribution. • Karstified limestone are good water yielder. • Friable sandstones in Barakars and Kamthis (Lower Gondwana) and their equivalent formations possess moderate to good ground water potential.
CONSOLIDATED FORMATIONS :			
Jurassic, Upper Cretaceous to Eocene	Rajmahal Traps, Deccan Traps	Basalt, Dolerite, Diorite and other acidic derivatives of Basaltic magma	Occur in West Bengal, Jharkhand, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka. Yield up to 5 liters per second. Unconfined shallow aquifers and leaky, confined deep aquifers

Pre-Cambrian (2500Ma to 541Ma)	Cuddapah, Vindhyan, Delhi and equivalent systems	a) Consolidated sandstone, shale, conglomerate b) Limestone, Dolomite c) Quartzite, Marble d) Intrusive Granites e) Malani Volcanics	Occur in all the states. Granites and granite gneisses with high secondary porosity-permeability and highly weathered zones forms productive aquifers.
Archaean (4000Ma to 2500Ma)	Archaean Complexes, Dharwar, Aravallis	f) Granite, Gneiss, Charnokites and Khondalite g) Schist, Slate, Phyllite, Granulite. h) Banded Hematite Quartzite (Iron ore series)	

PRINCIPAL AQUIFER SYSTEMS



LEGEND

Aquifers

- | | | |
|-----------|-------------------------|-------------------|
| Alluvium | Quartzite | State Capital |
| Laterite | Charnockite | State Boundary |
| Basalt | Khondalite | National Boundary |
| Sandstone | Gneiss | River |
| Shale | Intrusives | |
| Limestone | Banded Gneissic Complex | |
| Granite | Unclassified | |
| Schist | | |

Central Ground Water Board
 Ministry of Water Resources
 Government of India

TAYLOR'S (1959) CLASSIFICATION OF GROUND WATER PROVINCES OF INDIA

Geologic Age	Ground water Provinces	System/Formation	Hydrogeological Characteristics
Archean to Proterozoic	1. <u>PRECAMBRIAN CRYSTALLINE PROVINCE</u>	Delhi System, Dharwar group, Arawalli Systems	Occurrences generally in highly Weathered, Jointed, Fractured, faulted Zones, Large diameter dug Well,
Archean to Proterozoic	2. <u>PRECAMBRIAN SEDIMENTARY PROVINCE</u>	Cuddapah System, Vindhyan and Kurnool System, Raipur and Indravati Series	Weathered, bedding planes, Joints, Solution passages in Karstified zones, Dug wells up to 50m depth.
Late Carboniferous to early Cretaceous	3. <u>GONDWANA SEDIMENTARY PROVINCES</u>	Gondwana System, Jabalpur series, Himmatnagar sandstone, Umia, Series, Lathi Series	Structural Basins, Grabens, faulted and Folded belt, Dug wells, Tube wells, Rotary drilling, Constitutes Prolific aquifers at some favorable places.
Late Cretaceous to early Eocene	4. <u>DECCAN TRAP PROVINCES</u>	Deccan Traps, Basalt flows and Intertrappean beds	Volcanic products, Intertrappean beds, Weathered- vesicles, Jointed, Contact zones, Dug well, Bore well,
Eocene to Pliocene	5. <u>CENOZOIC SEDIMENTARY PROVINCE</u>	Palna and Nagaur Sandstone, Cuddaoure, Rajamundry and Athgarh sandstones, Quilon, Dwaraka beds	Coastal plains, Artesian aquifers, Saline at some places, Moderate to good ground water yield potential.
Pleistocene to Recent	6. <u>CENOZOIC FAULT BASINS</u>	Narmada and Tapi, Purna rivers valley	Valley filled deposits, moderate yield potential, saline in some places
Late tertiary to recent	7. <u>GANGA-BRAHMAPUTRA ALLUVIAL PROVINCE</u>	Vast plain of Ganga-Brahmaputa river and tributaries, enormous Alluvium deposits in the foredeep between the Himalayas and the Peninsula	Thick-widespread alluvium deposits, thickness could be reach .>1000m, Bhabar, Terai and Axial belts, line of Springs, well sorted, high porosity and permeability, Dugwell, tube well, percussion, rotary drilling, Prolific Aquifer formations, high yield potential

Archaean to Recent	8. <u>HIMALAYAN HIGHLAND PROVINCE</u>	Varied rocks types, sandstone, Slate, Limestone, Shale Granites, Metamorphic variants	Intensely folded, faulted valleys, deep gorges, Springs, Dug wells, yield could reach to 100 to 200m ³ /h at thick alluvium formations.
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India is a vast country with complex geologic, geomorphologic, climatic and tectonic settings which develops variety of hydrogeological and hydrochemical aquifer systems. The Water bearing rock formations range in age from Archaean to Recent.

With respect to ground water storage, yield potential, movement and other hydrogeological characteristics, rock formations can be broadly classified as two groups.

- POROUS FORMATION
- FISSURED FORMATION

1. POROUS FORMATION

A. Unconsolidated Formation

- Fluvial, Aeolian, Glacial, Lacustrine, Marine:
 - Boulder, Gravel, Sand, Silt, Clay
 - High to very high Porosity-Permeability and Specific yield potential.
 - Indo-Gangetic-Brahmaputra alluvial plain, East and West coast of India,
 - River deltas of India, Valley fills.

B. Semi-Consolidated Formation

- Mostly in narrow valleys
- Structurally Faulted basins
 - Gondwanas, Lathis, Tipam, Cuddalor sandstone and their equivalents.

2. FISSURED FORMATION

A. Plutonic Igneous and Metamorphic rocks (excluding volcanic and carbonate rocks)

- Granite, Gneiss, Charnockites, khondalites, Quartzite, Schists, Phyllite, Slate etc.
- Possess negligible primary porosity
- Secondary Porosity-permeability due to Fractures, Joints, Weathering.
 - Spread in almost every parts of the India, Peninsular India.

B. Volcanic rock

- Basalt flow, Intertrappean beds,
- Primary porosity due to Vesicular voids, tuff, Ash Breccia, volcanic pipes and tunnels.
- Permeability due to weathering, Columnar fractures, joints, Interflow contacts.
- Poor to moderate Yields, some places good yield potential.
 - Central and Western parts of India: Maharashtra, Madhya Pradesh, Karnataka, Andhra pradesh, Gujarat, Rajasthan

C. Consolidated Sedimentary rock (excluding carbonate rocks)

- Sandstone, Quartzite, Conglomerate, Shale
- Bedding planes, Joint openings, fractures
 - Cuddapah, Vindhyan, and equivalents

D. Carbonate rock

- Limestone, Dolomites, Calcareous Shale, Marbles
- Solution cavities, Sink holes and Caverns
 - Cuddapah, Vindhyan, Bijawar group of rocks

Taylor's classification of Groundwater Provinces (1959)

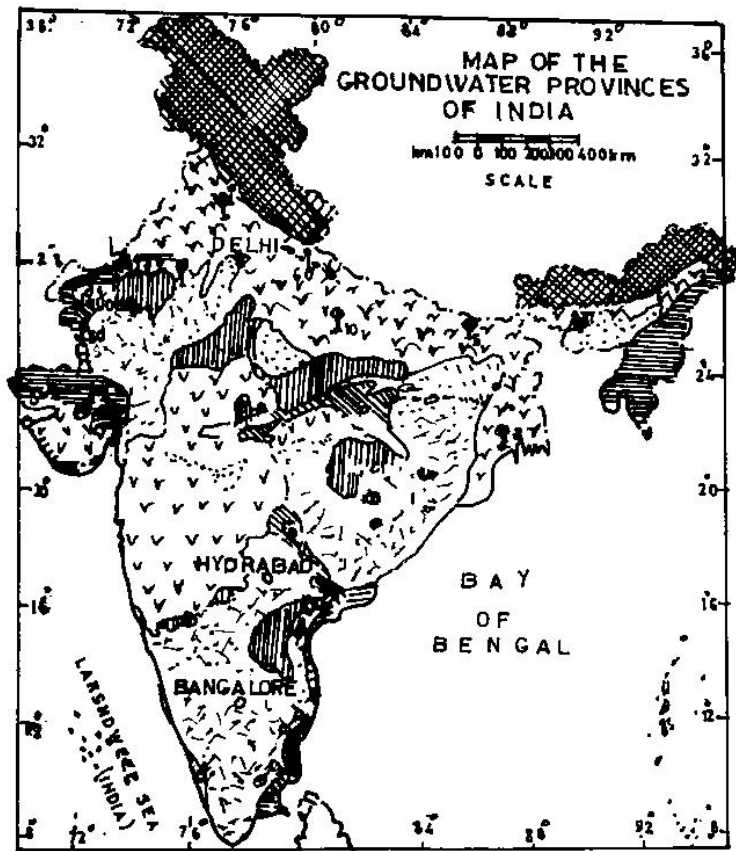
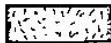
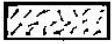

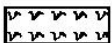


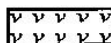



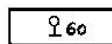


Fig. 2.29. Map of groundwater provinces of India.

Precambrian crystalline provinces		Cenozoic fault basins	
Precambrian sedimentary province		Ganges Brahmaputra alluvial province	
Gondwana sedimentary province L—Lathi series B—Bhuj series G—Other Gondwanas		Himalyan highland province	
Deccan trap province		Cenozoic fault basin	
Cenozoic sedimentary province P—Palau sandstone, C—Cuddhiore sandstone, R—Rajhmunday sandstone		Free Flowing well	
		Well indicating general depth of water flow below G.L. in m.	

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