DSPMU UNIVERSITY, RANCHI.
DEPARTMENT OF GEOLOGY

M.Sc. SEMESTER-IV **DATE-26/05/2020**
PAPER - CC GEOL 401

PROSPECTING CRITERIA OF VARIOUS MINERAL DEPOSITS

In the search for mineral deposits it is impossible to examine in detail every square km of the area or country by, for example, drilling. This would be too expensive, time-consuming and in most cases pointless. An area where the required mineral resources can be expected to occur is therefore delimited using prospecting criteria, that is, geological features which directly or indirectly suggest the presence of a given deposit.

Under prospecting criteria are summarized practical conclusions on stratigraphy, the petrography of sedimentary, igneous and metamorphic rocks, tectonics, structural geology and the facies concept, geochemistry, geomorphology, hydrogeology, geophysics, history and mining geology.

There are different criteria according to the branch of science in which it is employed -

1. Stratigraphic criteria
2. Structural criteria
3. Lithological criteria
4. Metamorphogenic criteria
5. Magmatogenic criteria
6. Geomorphological criteria
7. Paleogeographical criteria
8. Paleoclimatic criteria
9. Historical criteria

1. Stratigraphic criteria

If a mineral deposit is associated with certain well defined horizon/strata/beds of a particular age then it is referred as Stratigraphic criteria. For example, Throughout the world, deposits of coal, sedimentary copper ore, uranium, lead and zinc, pyrite, sulphur, phosphates and bauxite, sedimentary iron and manganese ores, placers, clays, carbonates, vanadium and salts are restricted to several definite stratigraphical horizons. In India economic deposits of iron ore (hematite) occurs in the iron ore series of the country. Mn deposits are found in kodurite and gonditic rocks of Archean age only.

2. Structural criteria

The structure of the earth's crust is often a controlling factor in the formation of ore deposits. Certain mineral deposits are confined by geographic, geological and tectonic features which will help us to understand the occurrence and exploration of ore deposits, and it is referred as structural criteria.

The porphyry type of Cu, Mo, Pb, Zn, Au, Ag deposits of western parts of South America, in parts of Peru, Chili, Columbia are of subduction zone origin.

Majority of ore deposits are generally formed in structural features such as fissures or fractures which serve as loci in themselves and as channel ways of hydrothermal solutions, and if the wall rock is favourable- mineralization results. For example, base metal sulphide deposits of Sargipalli, Odisha.

Numerous types of metallic and non-metallic deposits of endogenic origin, for example, are confined to folded areas or, more precisely, to the magmatic bodies intruded into them. These deposits usually originate in the last orogenic cycle within an area.

In contrast, coal, oil, carbonates, manganese, bauxite and some phosphate deposits are also found in transitional areas characterized by slight folding and cupolas. Oil and gas deposits are generally associated with anticlines. Structural conditions also influence the formation of coal deposits, which often occur in tectonic depressions such as grabens or synclinal zones. Brown coals occur on platforms only. Bituminous coals are generally confined to folded regions.

3. Lithological criteria

These are based on the paragenetic association of economic minerals with definite rock types. E.g.- Tin, muscovite, lithium, tungsten, gold, beryl, gemstones etc are associated with intermediate and acid rocks like syenite, granite, granodiorite etc. Deposits of copper, nickel, cobalt, silver, arsenic and apatite are formed in basic rocks like gabbro, norite, diorite etc. Deposits of asbestos, talc and magnesite are associated with ultrabasic rocks metamorphosed by the action of hydrothermal solutions, such as serpentinites. Chromite, platinum, diamond and corundum deposits are associated with ultrabasic rocks such as dunites, peridotites etc.

Prospecting experience has shown that carbonate rocks do not contain major Sn, Cu and Au deposits (in contrast to Pb, Zn); that telethermal Cu deposits of the "red beds" type, in so far as they are not considered as sedimentary, are associated with sandstones, in contrast to telethermal Pb-Zn deposits which prefer carbonate rocks; that hydrothermal U^{4+} ores occur in rocks containing minerals with Fe^{2+} (diabase, chloritic and hornblende schists), and that Pb-Zn ores are common in quartzites and Au ores in chloritic rocks.

The lithology of rocks is of special importance for deposits of the placer type. In depressions of river beds, produced by the selective erosion of lithologically variable rocks, the natural washing of the alluvium results in the accumulation of heavy minerals and the formation of placers (For example, gold).

4. Metamorphogenic criteria

Metamorphic deposits form due to mobilization and concentration of elements during regional and contact metamorphism. Metamorphosed deposit types are numerous, especially among pre-Palaeozoic and Palaeozoic sedimentary or magmatogenic deposits (e.g. the regionally metamorphosed Krivoi Rog Fe-deposit, U.S.S.R.; the Broken Hill Pb-Zn deposit, Australia; the Witwatersrand gold deposit, Rep. South Africa; the contact-metamorphosed Kowary Fe deposit, Poland; the Sonora graphite deposit, Mexico; and the Naxos emery deposit, Greece).

The metamorphic facies are a criterion for metamorphic deposits. For example, Deposits of native copper are associated with zeolite facies (Lake Superior, U.S.A.); magnetite-hematitic-quartzites and Au, U, sulphides, emery, amorphous graphite and asbestos deposits with greenschist facies; silicate Mn and Zn ores and magnetite-amphibole ores with the glaucophane facies; taconites and itabirites, Fe-ores, kyanite, sillimanite, andalusite, corundum, emery, crystalline graphite and ilmenite with hornblende facies; amphibole-pyroxene-magnetite quartzites, garnet, rutile with granulite facies; and rutile with eclogite facies.

5. Magmatogenic criteria

Study of the chemical composition of the magma, its differentiation and crystallinity, alterations in the country rocks, grain size of the igneous rock, the size and fabric of the intrusion and the depth of magma congealing is important in prospecting for mineral resources. Certain ores are characteristic of specific kind of igneous rocks whereas others show less consistent affiliation. For example, Sn, W, and Mo ores are characteristic of igneous intrusive (Bolivia, Nevada, U.S.A., Canada). Basic and ultrabasic magmas have a sufficient quantity of ore elements (some of them making the rock melanocratic) but are deficient in volatiles. Because of this they do not contain deposits formed by the concentration of ore elements through the co-action of volatiles, but rather deposits of Pt, Os, Ir, Cr, Ti, Ni and Cu ores. These elements do not form volatile compounds but accumulate in the basal part of the igneous body during magma differentiation and form segregation deposits. In addition to the metals mentioned above, some industrial minerals such as diamond, asbestos, corrundum, talc and magnesite are associated with basic and ultrabasic rocks.

6. Geomorphological criteria

Geomorphological criteria are particularly important in the prospecting for ores particularily those thar require certain physiographic conditions for their formation, concentration and accumulation. E.g. placer deposits (for the presence of heavy minerals, gold and even radioactive minerals). Sinkholes may suggest the presence of gypsum or limestone deposits.

Topographic maps, aerial photograps may indicate/show peculiarities in relief eg. Narrow depression, terraced elevatios etc. which may be worth investigating by the prospector. For example, in Salem (India), all the magnetite deposits form continuous resistant bands of hill tops easily recognisable from a diatsnce.

7. Paleogeographical criteria

The paleogeographical factors that are significant in prospecting for mineral resources can be placed in several categories, each of which demands special attention.
These are:

- a). the relief of the source and accumulation areas,
- b) the climate,
- c) the ancient drainage pattern,
- d) the form of the shoreline,
- e) the direction of currents in the accumulation area (in the river, sea or lake), and
- f) the presence of volcanic centres.

All these factors are affected by tectonism.

Particular attention should be directed to the peripheries of peneplain areas since these are potential sites of sedimentary chemogenic and biogenic deposits (bauxite, iron and manganese ores, salts, refractory clays, coal). Also of importance is the topography of the sedimentation area; for example, refractory clays and diatomites often form at the centre of a lacustrine basin, whereas bauxite and iron and manganese ores are confined to its margins. Karstic depressions are particularly favourable for the accumulation of iron and bauxite. The determination of the course of old river valleys is especially useful in the search for placers and Cu and U deposits.

8. Paleoclimatic criteria

Palaeoclimatic criteria are particularly important in prospecting for deposits related to weathering crusts. The residues of some rocks are enriched through weathering with poorly migrating elements to form economically valuable accumulations, such as Ni-hydrosilicates on serpentinites, Al-rich latentes on rocks poor in Fe, kaolins on feldspathic rocks, Mn-oxides on Mn-rich rocks (e.g. gondites) and gossans with Au, Pb and Fe on the corresponding primary deposits. This type of weathering has occurred since the oldest geological periods; kaolin, for example, has been formed in post-orogenic phases since the Carboniferous.

Residual and many sedimentary deposits form in a tropical climate. The re-deposition of a weathering crust rich in Al minerals gives rise to bauxites. Sedimentary Mn and coal deposits also formed in a humid climate. The formation of the majority of coal deposits during three principal periods — the Carboniferous, Permian to Jurassic, and the Late Cretaceous to Tertiary — can be explained, like the formation of thick weathering crusts, by extraterrestrial effects (e.g. an increase in solar activity) or, as is more probable, by planetary events (e.g. orogenies accompanied by intensive volcanism and changes in the configuration of the earth's surface). In periods of slight arid weathering fewer deposits of sedimentary iron ores were formed, since the small quantities of iron liberated by exogenic agents remained in the weathering crust and were not transferred to sedimentary basins (Devonian, Permian). The presesnce of red sandstone indicate arid climate.

9. Historical criteria

Historical criteria include written reports on ancient mining, old mine maps, archaeological finds (hammers, chisels, lamps, remnants of timbering), traces of old mine workings, relics of old dressing and smelting plants, slag heaps and local names. E.g.- Old mine dumps and shafts were among the factors which led to the selection of the area of Tynagh (Ireland) for geochemical work, induced-polarization geophysics and drilling, resulting in 1961 in the discovery of a Pb-Zn ore body hidden beneath 2-12 m of glacial drift. Europe's largest lead-zinc mine -Mogul in Ireland-was found by geologic mapping, geochemical soil sampling and geophysical work in Silvermine Mts. which have been a mining site for a thousand years. Gortdrum (Ireland) Cu-Ag ore body discovered by modern prospecting methods is situated close to Miner's Hill and 5 km from old Oola Hills mine (Peters, 1978).