

Quadrant II – Transcript and Related Materials

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Notes

OXIDATION AND SUPERGENE ENRICHMENT

When ore deposits become exposed to the oxidation zone, they are weathered and altered along with the enclosing rocks. The surface water oxidised many ore minerals and yield solvents that dissolved other minerals. An ore deposits thus becomes oxidised and generally leached off many of its valuable materials down to the groundwater or to a depth where oxidation cannot take place. The oxidised part is called the zone of oxidation. The effect of oxidation however may extend far below the zone of oxidation. As the cold dilute leaching solutions trickle downward, it may lose a part or all of its metallic content within the zone of oxidation and give rise to oxidised ore deposits. If the down trickling solution penetrate the water table , their metallic content may be precipitated in the form of secondary sulphides to give rise to a zone of secondary or supergene sulphide enrichment. The lower unaffected part of the deposit is called primary or hypogene zone.

This zonal arrangement is characteristic of many mineral deposits that have undergone long continued weathering.

Oxidation and supergene enrichment go hand in hand. Without oxidation there can be no supply of solvents from which minerals may later be precipitated in the zone of oxidation or of supergene sulphides. The process therefore resolves into three stages.

- 1) Oxidation and solution in the zone of oxidation.
- 2) Deposition in the zone of oxidation.
- 3) Supergene sulphide deposition.

The effects of oxidation on mineral deposits are profound. The minerals are altered and the structure is obliterated. Water with dissolved oxygen is the most powerful oxidising agent, but carbon-dioxide also plays an important role.

There are two main chemical changes within the zone of oxidation.

- 1) The oxidation, solution and removal of the valuable minerals and
- 2) The transformation of metallic minerals into oxidised compounds.

Since oxygen has no action on gold as well as other insoluble minerals like cassiterite, wolframite, etc, these minerals remain in the outcrop without any change and are enriched upon concentration of volume. Much of the soluble minerals are naturally removed by running water. Newly formed compounds are precipitated due to reactions between solutions, by hydrolysis, by coagulation, as well as by reaction between the solution and the solids.

FACTORS CONTROLLING OXIDATION:

- 1) Water table: Since oxidation takes place above the level of water table, the position of water table affects oxidation to a greater extent.
- 2) Low rate of erosion favours oxidation.
- 3) Warm humid climate with evenly distributed rainfall favours oxidation.

- 4) To some extent the chemical composition of the rocks and the associated structural features also control oxidation.

DEPOSITS IN THE ZONE OF OXIDATION: In the zone of oxidation, if the down trickling solution encounter precipitants above the water table, the mineral deposits may takes place. The mineral deposits redeposited in this zone are chiefly carbonates, silicates, and oxides. The common metals are Cu, Zn, Pb, Ag, vanadium and uranium.

GOSSAN: Oxidation, solution and consequent downward movement of the valuable minerals lead to the concentration of residual materials and some of the desiccated products of oxidation upon the surface, where the ore body had its outcrop and these together form a hard mantle known as gossan or cap rock.

The gossan is made up principally of limonite, gangue minerals and some of the oxidised products of the ore minerals. Sometimes false gossans are however produced as a result of precipitation of extraneous ferruginous solutions upon the exposed surfaces of the country rocks.

But in the majority of the cases, gossans supply many decipherable inferences as to the size, character and mineral contents of the hidden ore deposits. Therefore gossans are considered as a sign boards of oxidised as well as enriched zones beneath the surface.

SUPERGENE SULPHIDE ENRICHMENT :The metals in solution that escape capture in the oxidised zone trickle down to where there is no available oxygen, generally the water table, and there undergo deposition as secondary sulphides. The metals removed from above are thus added to those existing below, thereby enriching the upper part of the sulphide zone. This forms the zone of secondary enrichment or as it is now generally

referred to, the supergene sulphide enrichment zone. It is underlain by the primary or hypogene zone.

Progressive erosion permits deeper oxidation, and after a time the supergene sulphides themselves become oxidised, and their metal content is then transferred to the downward progressing enrichment zone. The primary ore thus may be enriched to as much as ten times to its original metal content. Rich ores are made richer, lean ores are made valuable and non-commercial primary material is built up to commercial grade. The process is therefore not only of great scientific interest but also of far reaching economic importance to the mineral industry.

REQUIREMENT FOR SUPERGENE ENRICHMENT:

Favourable conditions must exist for supergene sulphide enrichment to take place.

- 1) **Oxidation:** Oxidation of ore deposits may occur without attendant sulphide enrichment, but enrichment cannot take place without accompanying oxidation. Therefore, oxidation is the primary requisite and the factors that have been shown to favour oxidation must be present.
- 2) **Suitable hypogene / primary minerals:** The deposits must contain primary minerals which upon oxidation yield the necessary solvents. Iron sulphides are essential, and deposits lacking them rarely contain supergene sulphide zones. The primary ore also must contain metals that can undergo supergene enrichment. e.g. Cu, Ag, etc.
- 3) **Permeability:** Permeability of the ore deposits is essential to enable trickling solutions to penetrate beneath the zone of oxidation.
- 4) **Absence of precipitants in the zone of oxidation:** The oxidised zone must be free from precipitants, such as carbonate rocks, that fix the metal content of the enriching solutions in the form of oxidised compounds.
- 5) **Zone of No available oxygen:** Supergene sulphides can be deposited only where oxygen is excluded (i.e. in reducing conditions, Eh should be very low -0.2 to - 0.04). Generally

this is below the water level. Under certain circumstances, oxygen may also be lacking within the oxidised zone, and sulphide deposition may then take place there.

- 6) **Precipitants:** Supergene sulphides are deposited from sulphate solutions only at the expense of other sulphides, or similar minerals and by replacing them. Generally the underlying ore minerals are essentially hypogene minerals for deposition of supergene sulphides. If the down trickling sulphate solutions do not encounter sulphides in zones lacking available oxygen, the sulphates becomes dissipated, and no supergene sulphide enrichment occurs.

RELATION OF ENRICHMENT TO WATER TABLE: Sulphide enrichment starts at the water table and extends far below it. The position of the top of the zone is thus controlled by the water table and is similarly related to the topography. The upper surface may be sharply separated from the oxidised zone, but generally there is an interpenetration of the two. The surface may be generally curved or highly irregular and deeply penetrated by long roots of oxidised material. The bottom of the enrichment zone is highly irregular and is gradual transition to the primary ore. In places it terminates abruptly downward against impervious faults, or it may send roots downward along faults or other structural features.

SULPHIDE ENRICHMENT ABOVE WATER TABLE: Sometimes above the water table, the supply of oxygen may be consumed by the exteriors, and supergene sulphides may be deposited in the oxygen free interior.

SUBSIDING WATER TABLE: Under normal, slow sinking water level, coincident with erosion, the upper part of the sulphide enrichment zone is progressively enriched. A rising water table causes cessation of sulphide enrichment.

FACTORS INFLUENCING SULPHIDE ENRICHMENT:

Water level: A high, stationary water table, such as occurs in humid regions, means a thin zone of oxidation, little metal dissolved and give rise to a thin but well enriched supergene sulphide zone a deep water table, especially one being slowly depressed, favours a thick and well enriched supergene sulphide zone.

Primary ores: Supergene enrichment is dependent upon the enriching solutions making contact with primary ore precipitants. In disseminated copper deposits, which are permeable, there is a little chance of the enriching solutions escaping contacts with copper. In inclined vein deposits the enriching solutions may escape vertically downward and not encounter any hypogene sulphides, and little sulphide enrichment results. In steep veins, the enrichment zone is much wider than the hypogene vein. In general, the higher the grade of the primary ore the greater the degree of enrichment.

Structure: Faults have the same effect on enrichment as on oxidation. Large fault zones generate deep roots of enrichment.

Erosion : Rapid erosion may outstrip oxidation and little enrichment results; instead, the enrichment zone may be destroyed. Very slow erosion results in an almost stationary water level and a thin but rich supergene sulphide zone. The optimum condition of erosion for rich and thick supergene sulphide zone is a rate just about equal to the rate of oxidation and solution. This results in a continuous supply of enriching solutions.

Time : Considerable geologic time is necessary for extensive sulphide enrichment. (i.e. long crustal stability)

CESSATION OF ENRICHMENT :

The bottom of the zone of enrichment is ever moving downward, and it will continue to move downward as long as fresh supplies from above are received and hypogene ores lie beneath.

Obviously, it must cease somewhere. Cessation is brought about by number of means.

- 1) **Burial** : Burial beneath a thick cover of sediments or volcanic, prevents further oxidation and enrichment.
- 2) **Submergence**: Submergence of the oxidised and enriched zone beneath the water level causes the enrichment to cease.
- 3) **Bottoming of ore: when** sulphide enrichment in its downward progression reaches the bottom of the hypogene metallization, no more precipitants are available and enrichment ceases.

RECOGNITION OF SULPHIDE ENRICHMENT :

The recognition of sulphide enrichment is not always simple because many single features or characteristics of it are also common to hypogene mineralization. Therefore, combine rather than single criteria should be used.

Zoning : The three superposed zones- oxides, supergene sulphides, and primary/ hypogene- characterized enrichment.

It should be realised that hypogene processes also give rise to ore zones, such as the rich near – surface zones. Therefore, one must be able to distinguish between supergene and hypogene zoning.

A supergene sulphide zone generally related to the water table and therefore, conforms to a present or past erosion surface. Also supergene enriched zones are marked by a pronounced difference in mineralogy from the underlying zones , where as rich hypogene zones differ from the underlying leaner zones by a difference in amount rather than in kinds of minerals present.

Thus the process of oxidation and supergene enrichment produces the following :

(a)Gossan

(b)Zone of oxidation and leaching

- (c) Supergene sulphide enrichment**
- (d) Zone of enriched primary ore.**