ORIGIN OF THE MINERAL DEPOSITS

VOLCANIC EXHALATIVE PROCESS

Group No 03

Ore is solid naturally occurring body metallic ferrous mineral or aggregate with metallic ferrous mineral more or less mixed with gangue mineral and it should mine economically extract.

When concerning the processes of formation of ore bodies, it can be subdivided into two main processes as

1. Primary Processes
2. Secondary Processes

So these processes can be subdivided further more as follows.

Theories of ore formation

Primary Processes	**Secondary Processes**
INTERNAL PROCESSES	EXTERNAL PROCESSES
Magmatic Crystallization	Mechanical Accumulation
Magmatic segregation	Sedimentary Precipitation
Lateral Segregation	Residual Process
Hydrothermal Process	Secondary ore supergene
Metamorphic Process	Enrichment
	Volcanic Exhalative process

More than one above processes is responsible in forming of an ore body. Today we have to discuss about the Volcanic Exhalative (Sedimentary Exhalative) Process.

VOLCANIC EXHALATIVE PROCESS(SEDIMENTARY EXHALATIVE PROCESS

This is exhalations of sulfide rich magmas at the surface, usually under marine conditions. The deposits form from this process can be known as volcanic exhalative Deposits. These are group of deposits which are known as exhalities including massive sulfide ores. These ores frequently shows a spatial relationship to volcanic rocks. These Volcanic associated types principle constituent is Pyrite with varying amount of copper, Lead, Zinc & Barite together with other minerals may be present. For many decades they were concern as epigenetic replacement hydrothermal ore bodies which, a deposit introduced into the host rocks at some time after they were deposited .But later they were concern as syngenetic which A deposit formed at the same time as the rocks in which it occurs.

But all the ores are not spatially related with volcanic rocks .As an example Sullivan deposit in Canada is sediment hosted and the related similar deposits coming under this type known Sedex (Sedimentary Exhalative Deposits) which are conformable and frequently banded. Sedex deposits are a major source of minerals including copper, silver, gold and tungsten- and the single most important source of lead and zinc.

The above mentioned submarine Exhalative, sedimentary ore bodies and deposits can be observed in the process of formation of hydrothermal vents (Black Smokers) at large number of places along sea floor.

Black smokers are plums of hot and black which black smoke is colored by a high content of fine grained metallic sulphide particles. Some times they are white which colored by Ca, Ba & Sulphates .They issue hydrothermal fluid from chimney like vents which connect the fractures in the sea floor. Chimneys which less than 6m high and 2m across stand on mound of ore grade sulphides.

Black Smoker-Snake Fit Sulfide Deposit Mid Atlantic Ridge at 23 degrees North

The ores with volcanic affiliation show a progression of types. They are

1) CYPRUS TYPE

- Associated with basic volcanic
- In the form of ophiolites.
- Formed at oceanic or black arc spreading ridges
- Essentially cupriferous pyrite bodies
- Ex- Deposits of Toodos Massif in Cyprus, Ordovician Bay of Island Complex in New Found.

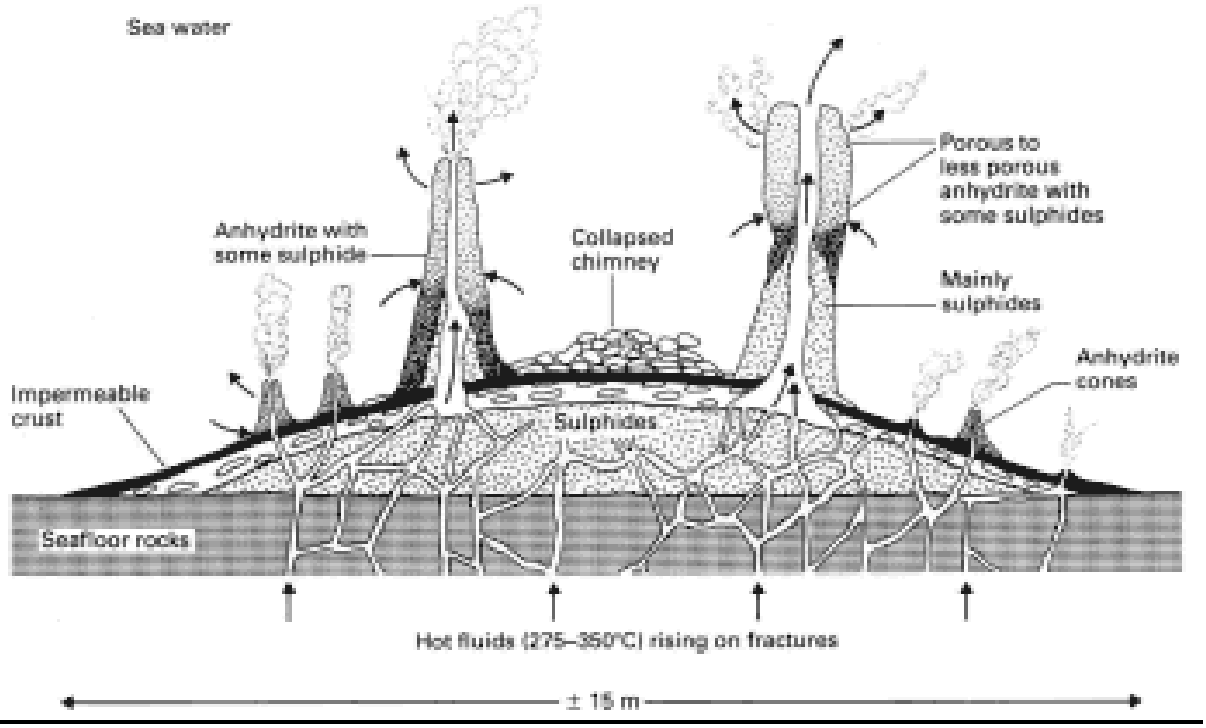
2) BESSHI TYPE DEPOSITS-

- Occurs in successions of mafic volcanic which characterized by thick gery wack sequences.
- Commonlu Zn,Cu deposits.
- Ex –Paleozoic sanbagawa dposits in Japan,Ordovicial deposits in Folldal in Norway.

3) KUROKO TYPE DEPOSITS-

- More Flesic volcanic,developed at island arc evolution.
- Cu-Zn-Pb ores often carrying gold and silver
- Large amount of Barite,Quartz and Gypsum are associated with them.

FORMATION OF CHIMNEYS AND SULFIDE MOUNDS ON SEA FLOOR



Chimneys are started to grow up with the precipitation of anhydrate from cold sea water around the hot ascending plume. So it forms a porous wall that continuous to grow upward during the life of the plume. Small amount of hydrothermal fluid flows through the porous anhydrite wall while large amount is flows up the chimney, discharge as a plume in to the surrounding sea water.

In this process the hydrothermal fluid meet sea water penetrating the chimney from the outside which achieve closes conditions similar to normal sea water by,

- Become a high temperature(>300 Celsius)
- Become acidic (PH=4.5)
- Oxidized (H2S >>>SO2)

Because of anhydrate chimney grows upward the wall of lower part thicken by precipitation of sulphides in the interior portion, anhydrite on the out side. This process leads to a concentric zoning which,

- On the inside with Chalcopyrite
- Intermediate zone of Pyrite ,Sphalerite ,Wurzite and anhydrite
- Outer zone of anhydrite with minor sulphide, amorphous silica, barite.

This zoning occurs mainly because of temperature decreases across the wall than the other factors. The growing chimneys (8-30 cm a day), become unstable & Collapse with forming a mound of chimney debris mixed. This mound is grows both by accumulation of chimney debris on its upper surface and by precipitation of sulphides within the mound.

The covering of chimney debris performs the same role as the vertical porous anhydrite chimney walls producing sulphide and silica precipitation in the outer part of the mound. This decreases the permeability of the mound .It forms a crust that constrains fluid escape and leads to considerable circulation of high temperature solutions within the mound. The isotherms within the mound then rise. It leads to the replacement of lower temperature mineral assemblages by higher temperature ones, thus producing a similar zoning to that in the chimneys .Because of that of volcanic-associated massive sulphide deposits found on land.

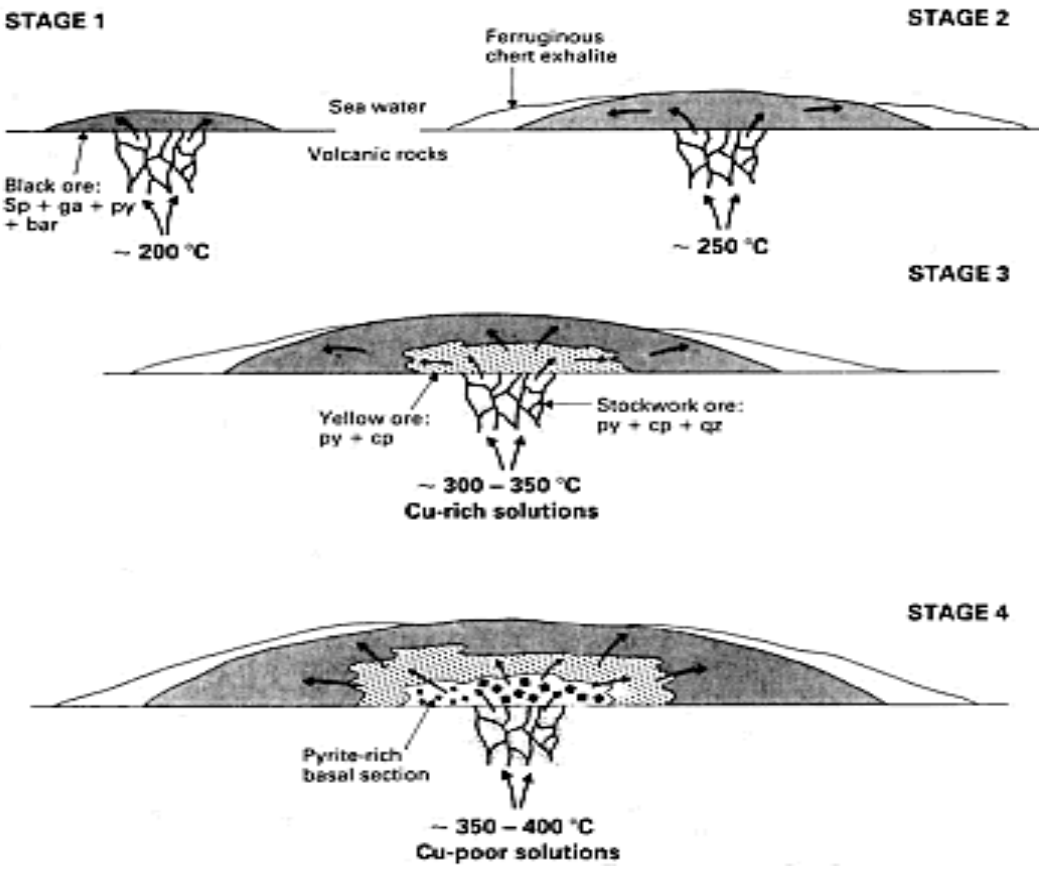
This is how the black smokers are formed. A most surprising feature of modem submarine hydrothermal vents is, it associated prolific biota and their food chain based on chemosynthetic bacteria.

There *is* a model which indicates the formation of volcanic-associated massive sulphide deposits.

Volcanic Associated Massive Sulfide Deposits

Volcanic-associated massive sulphide (VMS) deposits may have the mound shape of modem massive sulphide deposits or they may be bowl shaped. The latter type probably developed when hydrothermal solutions, more saline (denser) than the surrounding sea water, vented into a submarine depression. Many Cyprus-type deposits appear to have developed in this way.

<u>Stages of VMS development</u>



At the First stage,

Fine-grained sphalerite, galena, pyrite, tetrahedrite, baryte with minor chalcopyrite are precipitated by the mixing of relatively cool (~200'C) hydrothermal solutions with cold sea water.

Then the second stage,

Recrystallization and grain growth of these minerals at the base of the evolving mound by hotter (~250'C) solutions, together with deposition of more sphalerite, etc.

At third stage,

Influx of hotter (~300'C) copper-rich solutions which replace the earlier deposited minerals with chalcopyrite in the lower part of the deposit (yellow ore). Redeposition of these replaced minerals at a higher level.

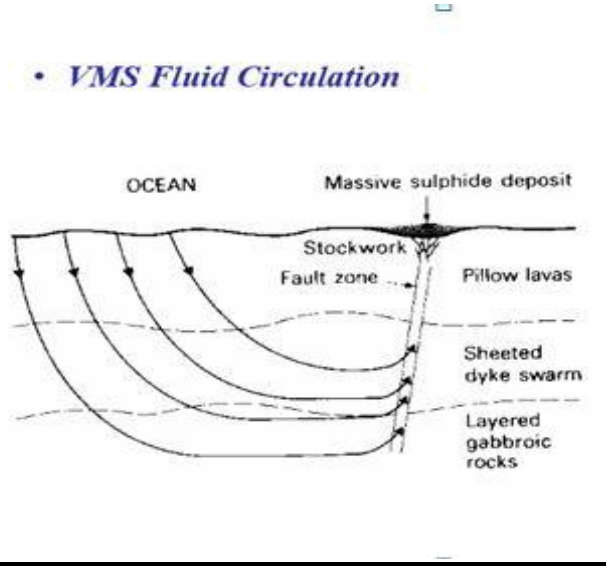
In stage four,

Dissolving of Still hotter, copper unsaturated solutions with some chalcopyrite to form pyrite-rich bases in the deposits.

At the last stage,

Deposition of chert-hematite exhalites above and around the sulphide deposit. Similar exhalities will also have formed during previous stages.

VMS FLUID CIRCULATION



This is the diagram showing how sea water circulation through oceanic crust might give rise to the formation of an exhalative volcanic-associated massive sulphide deposit.

Sketch of development of massive sulfide deposits on the sea floor

(a) A ponded hydrothermal solution whose density is greater than that of the surrounding sea water collects in a depression to form a bowl-shaped deposit.

(b) A solution less dense than sea water forms a sulphide mound and rises buoyantly above it to form a hydrothermal plume. From this, oxide and sulphide pal1icles and silica rain down on the surrounding rocks to deposit

ferromanganese oxide rocks, cherts with or without pyrite and other hydrothermal sedimentilry ilccumuliltions thilt ilre cill1ed exhalites.

DISTRIBUTION & EXAMPLES

1. Base metal deposits of Meggen, Germany
2. Sullivan, Canada

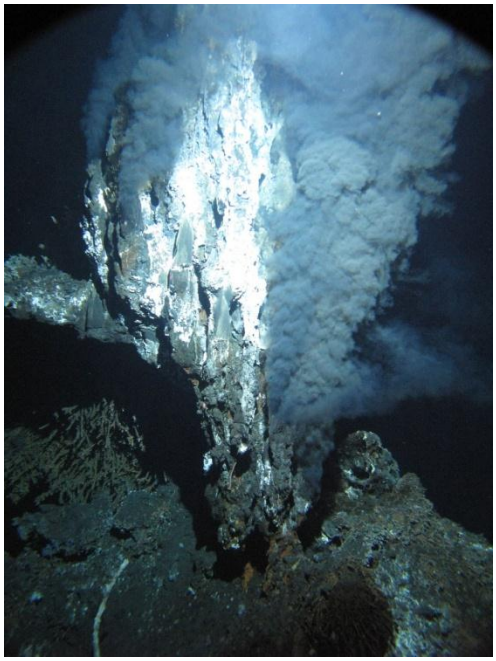
Sullivan Mine, Cominco World's Largest Underground Lead Zinc Mine

3. Mt Isa,Australia

4. Rio Tinto, Spain

5. Kuroku Deposits of Japan

6. Black smoker deposits of modern ocean



7. Mercury of Almaden,Spain

Almaden Mercury mine tunnel

8. Solfatara deposits,Sicily

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2) http://www.geol-amu.org/notes/b3-3-2.html

3)almed.edu.co/rrodriguez/Earth%20Resources/Black%20Smokers.html

4) Ore Geology and Industrial Minerals and Introduction, Anthony M. Evans,Blackwell Publishing,3rd edition

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