M.Sc. Geology SEM II, MGELCC 6

TOPIC: SEDIMENTARY BASINS AND THEIR CLASSIFICATION

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A sedimentary basin is structurally controlled morpho-tectonic depression capable of receiving and preserving sediments with a geological history not withstanding erosion and non deposition from time to time. A sedimentary basin represents a unit of geological structure which received sedimentary succession unique to it during a given span of time.

A sedimentary basin is characterised by:

1. a distinct sediment fill
2. single or multiple depositional environment and cycle
3. distinct tectonic framework and basin architecture which define the basin type
4. single or several phases of tectonic and/or thermogenic subsidence
5. One or more tectono-sedimentation episodes defining single or polyhistory basins.
6. Geological history indicated by sedimentation cycles of the basin fill vis-a-vis tectonic events ,subsidence/uplift and erosion.
7. Stratigraphic sequences related to tectonic episodes
8. Thermal history : thermo-tectonic events.

The style of evolution of a basin depends on the tectonic realm where it is located. It is therefore possible to group basins in genetic classes each characterized by its typical structural style ,sediment fill and evolutionary history depending on tectonic regimen to which it belongs. Thus, each plate tectonic setup is characterized by genetically related groups of basins whose structural styles depend on inter plate and intra plate movements typical of the setup in which they occur. The mechanism of the basin formation and its development therefore vary according to the tectonic processes of the setup.

Thus basins are classified and grouped under three plate tectonic processes:

1. Divergent

2. convergent

3. Transform setting

Characterized by extensional, compressional and horizontal stress related (strike slip)settings respectively.

Basins evolve with the plate movements and one type of basin may change into another type or abort and remain as a fossil basin depending on the stages of plate evolution. Thus post sediment life span of basins may vary.

RIFT BASINS: Intra continental rifting leading to a break up of continent and spreading of ocean generally takes place along the ancient orogenic belts and palaeo-sutures due to crustal extension and thining as a result of the rise of volcanic plume from upper mantle or uparching of mantle(active rifting) depending on the convecting asthenosphere.

Pericratonic rifts are located at the continental margins as shelfal horst/ graben complex after successful intra continental rifting and spreading of proto oceanic troughs.

Intra cratonic rifts develop within the continental crust forming rift valleys eg Gondwana basins. These basins are commonly associated with bimodal volcanism.

Failed rifts are aborted arm of the triple –junction rift system. After sucssesful rifting along the other arms leading to separation of continents and creation of proto oceanic troughs. Aulacogens are former failed rifts at high angles to continental margin which have been reactivated during convergent tectonics so that they are at high angles to the orogenic belts.

The basins adjacent to the emerging mid oceanic ridges are Active Ocean basins .

INTRA CONTINENTAL BASINS

Sag basins are formed by sagging of continental crusts due to crustal distension by far field deviatorial stress .mechanism of crustal distension is controversial. Subsidence could be caused by:

1.Increase in crustal density by Eclogite phase transformation.

2.Pre break up crustal distension by impingement of thermal plume

3.Thermal metamorphism of lower crust

4.mechanical subsidence by isistaticcompensation due to igneous intrusion.

5.Tectonic reactivation of older structure

6.Thermal subsidence

7.Partial melting of lower crust

8.Changes in Intra plate stress

9.Thermal subsidence caused by isostasically uncompensated excess mass of cooling igneous intrusions.

10.Subsidence caused by tectonic events at adjacent plate margins.

Rift related sag basins may be asymmetric with boundry faults developing interior fracture basins. Interior fracture basins are aborted rifts in continental set up after initial stages of development. Sag basins develop by pre break up distension of continental crust may develop into interior fracture basin before rift failure.

FORELAND BASINS

Foreland basins are formed in collision setup by Continent-Continent, Arc-Arc and Arc-Continent collision. A peripheral foreland basin is formed as the elastic lithosphere of the approaching continent flexes under the dynamic load of the frontal thrust belt of the overriding continent.

Retro-arc forland basin are formed by arc –continent collision and occur on the continent side of compressional arc formed during subduction of oceanic plate.

Intermontane forland basins are formed by basement cored uplifts in forland settings.

Inter-orogenic foreland basin occur between two orogenic belts involvingcollision of three continents .When two continents collide on either sides of a third continent overriding it,the common peripheral foreland basin between the two obducting continents becomes the inter orogenic foreland basin.

ARC – TRENCH BASINS

Fore arc trenches occur at the threshold of the ocean –arc subduction zone.The subsidence mechanism is controlled by negative buoyancy of the subducting oceanic lithosphere by slab pull forces and by isostatic tectonic load of the accretionary prism over the subduction zone.

Subsidence mechanism of fore arc basins can be combination of the following:

1.Bulk subsidence of the whole fore arc region due to subduction of older and less buoyant oceanic lithosphere.

2.Flexural subsidence of forearc substratum under the growing tectonic load of the subduction complex.

Passive isostatic subsidence of initially thin fore arc crust under the growing sediment load of the fore arc basin itself.

Intra arc basins are located on the arc platform between volcanic fronts.The subsidence is caused by

1.Plate boundary forces

2.Relative Plate motions

3.Asthenospheric flow

4.Regional Isostasy

5.Magmatic withdrawl

6.Gravitational collapse

Back arc basin occur behind continent margin arc and behind intra oceanic magmatic arcs. They are produced by rifting between arc massifs during sea floor spreading. Back arc basins are basins occurring between Remnant and active arcs are called Inter arc basins.

Remnant Ocean basins are shrinking basins caught up between obliquely colliding continental margins and/or arc trench system,ultimately subducted or drformed within suture belts.

Superposed basins/Piggy back basins are formed on the thrust belts by interaction of thrust sheets and carried by moving thrusts.

TRANSTENSIONAL BASINS

These basins develop by lithosphere shearing resulting in dislocation or pulling apart of the lithosphere and hence called PULL APART BASINS. Such basins thus occur along trends of transform system wherever en echelon fault segments,curving faults or branching faults are arranged in a releasing orientation with respect to the direction of plate motion .

Equant pull-apart basins between en echelon transform segments or elongate fault wedge between branching faults are typical developments within simple shear stress system.Thus,such basins occur between parallel or overlapping strike slip faults or in their releasing bends, fraying ends or between the main and its conjugate fault systems

TRANSPRESSIONAL BASINS

These basins are formed by downwarping of lithosphere in constraining orientation with respect to plate motion in transformsegments.These basins thus occur with convergent strike slip faults along restraining bends with thrust margins that results in flexural subsidence due to tectonic loading.

TRANSROTATIONAL BASINS

These fault bound basins develop between blocks that rotate differentially in a shear zone around a sub vertical axis in the same direction of principal shear stress.Rotation is clockwise in right simple shear and anticlockwise in the case of left simle shear.Block rotation on sub vertical or vertical axis yields prominent triangular or rhomb shaped basins that may be quite extensive in the zones of distributed shear.

TECTONIC CLASSIFICATION OF SEDIMENTARY BASINS.

PROCESSES	SET UP	CLASS	TYPE
EXTENSIONAL	DIVERGENT	RIFT BASINS	Pericratonic,Intra cratonicrifts,Failed rifts& Aulacogens,Proto-oceanic troughs&Miogeoclinal prisms,Active & Dormant Ocean basins
		INTRA CONTINENTAL	Sag basins,Interior fracture basins.
COMPRESSIONAL	CONVERGENT	FORELAND BASINS	Peripheral ,Retroarc Intermontane,Inter orogenic foreland basins
		ARC TRENCH BASINS	Fore arc,Back arc &Intra arc basins,remnant ocean basin& superposed/piggy back basins
HORIZONTAL STRESS (STRIKE SLIP)	TRANSFORM	TRANSTENSIONAL	Pull apart basins
		TRANPRESSIONAL	Strikeslip related thrust bound sag basins
		TRANSROTATIONAL	Basins formed by block rotation in transform shear zones.