

Chapter 11

SEDIMENTARY BASINS

1. INTRODUCTION

1.1 The official definition of a *sedimentary basin* is: *a low area in the Earth's crust, of tectonic origin, in which sediments accumulate*. Sedimentary basins range in size from as small as hundreds of meters to large parts of ocean basins. The essential element of the concept is *tectonic creation of relief*, to provide both a source of sediment and a relatively low place for the deposition of that sediment.

1.2 Keep in mind that *a sedimentary basin doesn't have to be a place on the Earth's surface with strictly basinal shape*, with closed contours, like a washbowl: great masses of sediment can be deposited on a surface with a gentle and uniform slope. But implicit in the concept of a sedimentary basin is the existence of prolonged crustal subsidence, to make a place for a thick deposit of sediment that might well have been deposited in an area without basinal geometry at the surface. Tectonics is needed to make sedimentary basins, but the record of the basin itself is sedimentary.

1.3 As with most blanket statements, the one above has exceptions to it. A sedimentary basin can be made just by erecting high land in an adjacent area by volcanism.

1.4 The term "sedimentary basin" is usually not applied to relatively thin and very extensive deposits of sandstone, limestone, and shale from epicontinental seas on the cratons, many of which have seen no deformation through billions of years, but only to relatively thick deposits in tectonically active areas with negative relief. (But intracratonic basins are the exception in this regard.)

2. TECTONICS AND SEDIMENTATION

2.1 *Tectonics is the most important control on sedimentation*; climate is a rather distant second. The important effects of tectonics on sedimentation, direct or indirect, include the following:

- *nature of sediment*
- *rate of sediment supply*
- *rate of deposition*

- *depositional environment*
- nature of source rocks
- nature of vertical succession

2.2 In fact, *tectonics affects climate itself*, by way of effects as broad as the distribution of oceans and continents, and as local as rain shielding by local mountain ranges. And *sedimentation itself affects tectonics*, although to a much lesser extent, mainly by increasing the lithospheric loading in the basin.

2.3 The other side of the coin is that *by far the best way of telling paleotectonics is by the sedimentary record in sedimentary basins*. The disposition of sediment types, sediment thicknesses, and paleocurrents in a basin gives evidence of the existence and location of elevated areas of the crust created by tectonism.

3. QUESTIONS ABOUT SEDIMENTARY BASINS

3.1 Here are some important questions you might ask about a given sedimentary basin:

- What was the *size and shape* of the basin, and how did these change as the basin was filled?
- Is (was) the basin floored by *continental crust or oceanic crust*?
- What were the *kinds and proportions of sediments* that filled the basin?
- What were the *sources of the sediment*, and *by what pathways was it transported* to the depositional sites?
- What was the *history of filling* of the basin?
- How can the *original geometry* of the basin be distinguished from *subsequent deformation* of the basin?
- What was the *overall tectonic setting* of the basin?

4. PRACTICAL THINGS ABOUT BASINS

4.1 The only basins that are preserved in their entirety are those that lie entirely in the subsurface! Basins exposed at the surface are undergoing destruction and loss of record by erosion. So there's an ironic tradeoff between having more complete preservation in the subsurface but less satisfactory observations.

4.2 How do you gather data on sedimentary basins? There aren't many ways, really: surface mapping; cores; and subsurface geophysics, mainly seismic profiling.

4.3 What kinds of things can you do with the data, to help you answer some of the questions posed above? Here's a list of some the fairly standard things you can do. These range from very descriptive to very interpretive. It makes sense to do the descriptive things first and then work toward the more interpretive.

master cross sections: with the present land surface as the most natural datum, construct *several detailed physical cross sections through the basin* to show its geometry and sediment fill.

stratigraphic sections: construct a graph, with time along the vertical axis, showing *the time correlations of all the major rock units* along some generalized traverse across the basin. Such a section includes hiatuses, during which there was nondeposition or erosion.

isopach maps: with some distinctive stratigraphic horizon near the top of the section as datum, draw a *contour map showing isopachs (isopachs are loci of equal total sediment thickness)* in the basin.

lithofacies maps: for one or a series of times, draw a map showing *distribution of sediment types being deposited* at that time.

ratio maps: compute things like *sand/shale ratio*, integrated over the entire section or restricted to some time interval, and plot a contour map of the values.

paleocurrent maps: for one or a series of times, draw a map showing *the direction of paleocurrents in the basin* at that time (see below for more detail).

grain-size maps: for the entire basin fill, averaged vertically, or for some stratigraphic interval or time interval, draw a map that shows *the areal distribution of sediment grain size*. This is especially useful for conglomeratic basins.

4.4 Another interpretive thing you can do is draw diagrams (qualitative or semiquantitative) showing *the evolution of depositional–paleogeographic–paleotectonic setting of the basin*, by means of maps and sections. These could range from cartoons to detailed representations drawn to scale.

4.5 Just within the past ten years, computational techniques known as *backstripping* have been developed to “undo” the deposition in a sedimentary basin. This involves restoring the basin to a whole series of past configurations by removing one layer of sediment at a time and adjusting for compaction,

subsidence, and sea-level change. This lets you reconstruct the configuration of the basin through time, perhaps by drawing palinspastic cross sections for various time intervals. In a way, this is the next best thing to having in your possession a time-lapse movie of the entire development of the basin.

4.6 This is a good place to warn you about *vertical exaggeration of cross sections of sedimentary basins*. Cross sections are almost always drawn with great vertical exaggeration, typically somewhere between 10:1 and 100:1. This is because in true scale most basins are relatively thin accumulations, hundreds to thousands of meters of sediment spread over distances of tens to hundreds of kilometers. So to see the relationships adequately in cross sections, the sections have to have great vertical exaggeration. Carefully constructed sections show both the vertical and the horizontal scale, but cartoons often don't show the scales.

5. PALEOCURRENTS

5.1 Much effort has gone into developing ways of figuring out paths of dispersal of sedimentary material in basins. One of the standard ways is to measure paleocurrent directions recorded locally in the rocks. (A *paleocurrent* is just what the term implies: *a current, of water or wind, that existed at some time in the past.*) Techniques are well established.

5.2 Knowledge of paleocurrents is helpful in solving both local and regional problems of sedimentary basins. Locally, paleocurrent directions can help you to figure out or predict, indirectly, *the shape and orientation of sediment bodies*, like channel sandstones. This has obvious advantages in petroleum exploration. Regionally, paleocurrent directions can help establish *paleoslope* and *source of sediment supply to the basin*.

5.3 You have already heard about a lot of the features that can be used to establish paleocurrent directions. Here's a list of the most important, with annotations:

Cross-stratification. Measure the local orientation of laminae in the cross sets, on the theory that the local downdip direction, which presumably is the direction of progradation of the foreset slope, is likely to represent fairly closely the local current direction. That's true, however, only if the bed forms were reasonably two-dimensional. If the bed forms were three-dimensional, resulting in trough cross stratification, *measurement of foreset dip directions at local places in the cross sets can be very misleading*; it's much better to try to ascertain the orientation of the trough fills themselves, although it takes good outcrops to do that. Seeing rib and furrow is by far the most reliable way of obtaining a paleocurrent direction

from cross-stratified deposits, but unfortunately it's uncommon to see on outcrop.

Bed forms. If you are lucky enough to see bedding planes covered with symmetrical ripples or dunes, you can get an excellent measurement of current direction.

Clast orientation. Long axes of the larger clasts in a clastic deposit, whether gravel or sand, are commonly oriented by the current, although the orientation may be rather subtle. The problem is that the orientation relative to the current (flow-transverse? flow-parallel?) depends on the flow itself in ways not well understood. So beware of clast orientation in and of itself. Pebble imbrication is an exception, and should always be sought in gravels and conglomerates. (But see below under parting lineation.)

Sole marks. Flutes and grooves at the bases of turbidites and other strong-current-event beds give excellent evidence of the direction of the initial, eroding current. But keep in mind that the later current that did the depositing did not necessarily flow in exactly the same direction.

Parting lineation. Parting lineation is thought to reflect a subtle anisotropy in rock strength caused by a statistical tendency toward alignment of sand grains in a sandstone parallel to the current direction. It gives excellent evidence of the orientation of the current, but unfortunately not the direction.

5.4 The paleocurrent measurements you take from dipping beds are no good in themselves: what you need to do is “undeform” the strata by *rotating them back to horizontal, taking your paleocurrent measurements with them*. That's straightforward (using a stereonet by hand, or a computer program) provided that the strata are not strongly deformed. But the greater the deformation, the more uncertain is the exact way you should be undeforming the strata.

6. HOW BASINS ARE MADE

6.1 Introduction

6.1.1 In one sense, the origin of sedimentary basins boils down to the question of *how relief on the Earth is created*. Basically, there are only a few ways, described in the following sections.

6.2 Local

6.2.1 On a small scale, hundreds to thousands of meters laterally, fault movements can create relief of hundreds to thousands of meters, resulting in small but often deep basins (some of these are called *intermontane basins*; think about places like Death Valley). You might guess that it takes dip-slip fault movements to create new relief, but that's not true: steps (in the proper sense) along strike-slip faults can produce small *pull-apart basins*; more on them later. Relief of this kind is on such a small scale that it tends not to be isostatically compensated. It's like setting a block of granite out on your driveway; the flexural rigidity of your driveway is great enough compared with the imposed load that the granite block is prevented from finding its buoyant equilibrium position.

6.3 Regional

6.3.1 Basin relief can be created mechanically on a regional scale in two very important ways: *thermally* or *flexurally*, or by a combination of those two effects). Each of these is discussed briefly below. Keep in mind that basins can also be made just by making mountain ranges, on land or in the ocean, by volcanism.

6.4 Thermal

6.4.1 If the lithosphere is heated from below, it expands slightly and thus becomes less dense (Figure 11-1). This less dense lithosphere adjusts isostatically to float higher in the asthenosphere, producing what we see at the Earth's surface as *crustal uplift*. If the lithosphere cools back to its original temperature, there's isostatic subsidence back to the original level.

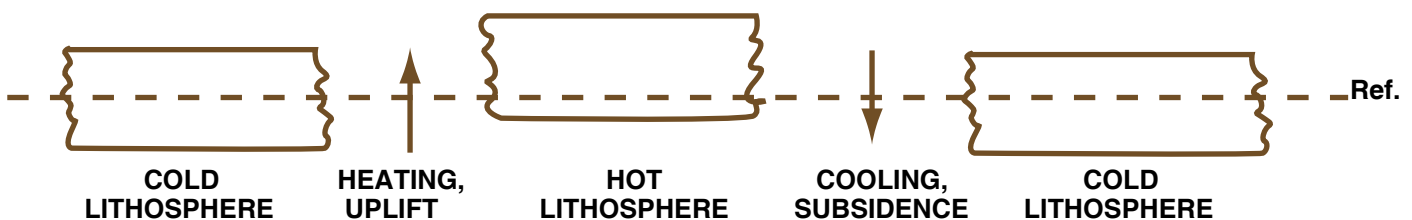


Figure by MIT OCW.

Figure 11-1

6.4.2 But suppose that *some erosion took place while the crust was elevated* (Figure 11-2). The crust is thinned where the erosion took place (and thickened somewhere else, where there was deposition; that might be far away, at the mouth of some long river system), so *when the crust cools again it subsides to a position lower than where it started*, thus creating a basin available for filling by sediments.

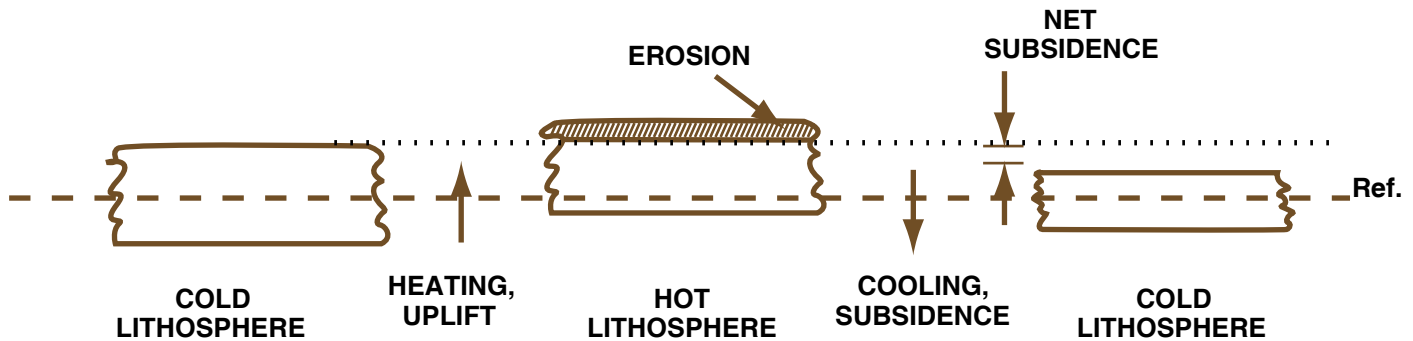


Figure by MIT OCW

Figure 11-2

6.4.3 But the magnitude of crustal lowering by this mechanism is less than is often observed in basins thought to be created thermally (Figure 11-3). It has therefore been proposed, and widely accepted, that in many cases extensional thinning of the lithosphere accompanies the heating. Then, *upon recooling, the elevation of the top of the lithosphere is less than before the heating and extension*. This kind of subsidence has been invoked to explain many sedimentary basins.

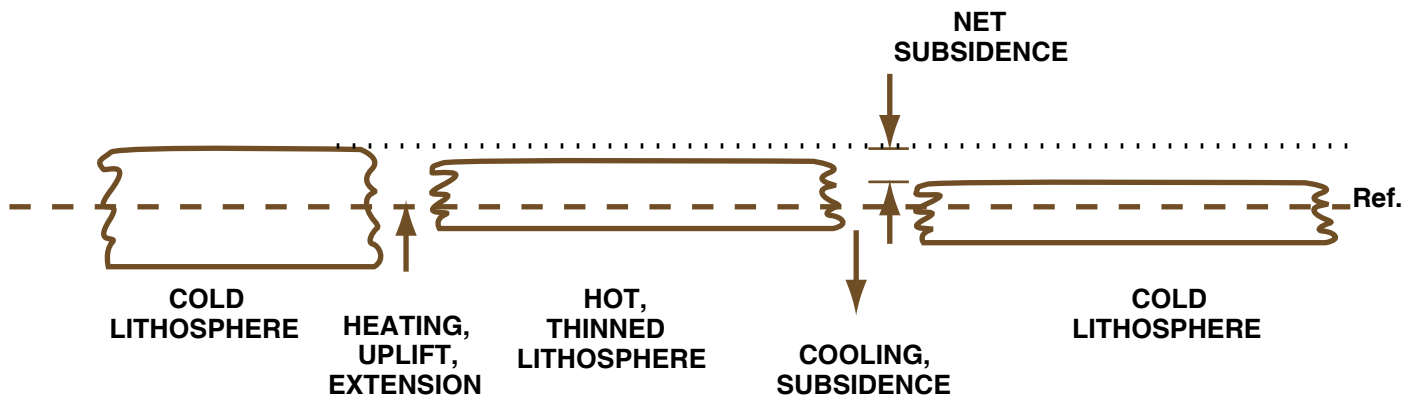


Figure by MIT OCW.

Figure 11-3

6.5 Flexural

6.5.1 Another important way to make basins is to park a large load on some area of the lithosphere (Figure 11-4). The new load causes that lithosphere to subside by isostatic adjustment. But because the lithosphere has considerable flexural rigidity, *adjacent lithosphere is bowed down also*. The region between the high-standing load and the lithosphere in the far field (in the parlance of geophysics, that just means far away!) is thus depressed to form a basin. This model has been very successful in accounting for the features of *foreland basins*,

which are formed ahead of large thrust sheets that move out from orogenic areas onto previously undeformed cratonal lithosphere.

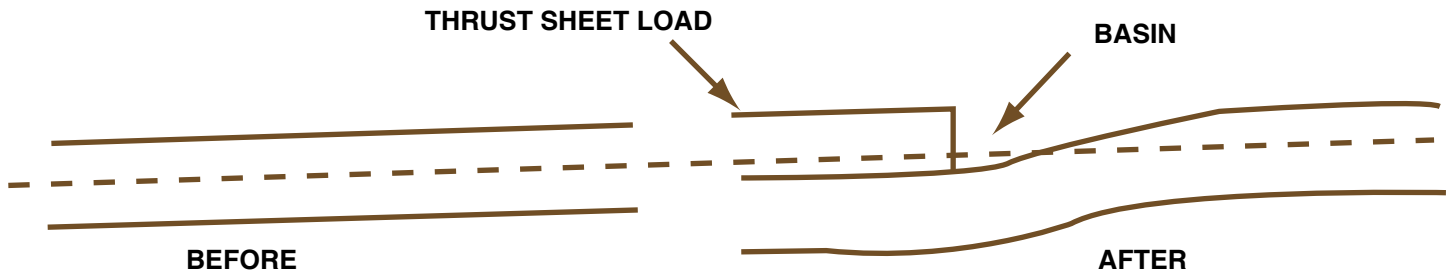


Figure by MIT OCW.

Figure 11-4

7. GEOSYNCLINES

7.1 The concept of geosynclines was developed in the last century to deal with the existence of thick successions of sedimentary rocks in what we would today call orogenic belts. A *geosyncline* is *large troughlike or basinlike downwarping of the crust in which thick sedimentary and volcanic rocks accumulated*. Usually, but not always, such accumulations are deformed during a later phase of the same geological cycle in which they were deposited. You can see by the definition that there is a close, although not one-to-one, correspondence between geosynclines and what we are discussing here as sedimentary basins.

7.2 The geosyncline concept was developed in an effort to understand the regularities of sedimentation in orogenic belts. Over the decades, in both Europe and North America, the concept was elaborated to an extreme degree, with lengthy classifications and polysyllabic terminology. The problem was that geologists were able to recognize distinctive kinds of sedimentary basin fills associated with orogenic belts, and characteristic histories of subsequent deformation of those sediment fills, but no one really knew the tectonic significance of geosynclines. The universal acceptance of plate tectonics has provided a rational framework in which to interpret the development and history of sedimentary basins once called geosynclines. Plate tectonics has simply made the geosyncline concept obsolete. (I'm mentioning it here just because it played such a large part in thinking about tectonics and sedimentation in past times.)

7.3 About the only term in common use that is left over from the heyday of geosynclines is *miogeocline*, for *the prograding wedge of mostly shallow-water sediment at a continental margin*. The sediment thicken sharply oceanward and pass into thinner deep-water sediments.

8. CLASSIFICATION OF SEDIMENTARY BASINS

8.1 Introduction

8.1.1 How might one classify sedimentary basins? Here's a list of some of the important criteria that could be used, ranging from more descriptive at the top of the list to more genetic at the bottom of the list:

nature of fill	more descriptive
geometry	
paleogeography	
tectonic setting	more genetic

8.1.2 Nowadays sedimentary basins are classified by tectonic (and, specifically, plate-tectonic) setting. That's fairly easy to do for modern basins, but it's rather difficult to do for ancient basins. (By modern basins I mean those still within their original tectonic setting; by ancient basins I mean those now separated from their original tectonic setting.) This emphasizes the need for good description and characterization, even if some kind of formal descriptive classification is not actually used.

8.1.3 In the following pages is a brief account of the most important kinds of sedimentary basins.

8.2 Intracratonic Basins

location and tectonic setting: in anorogenic areas on cratons (Figure 11-5).

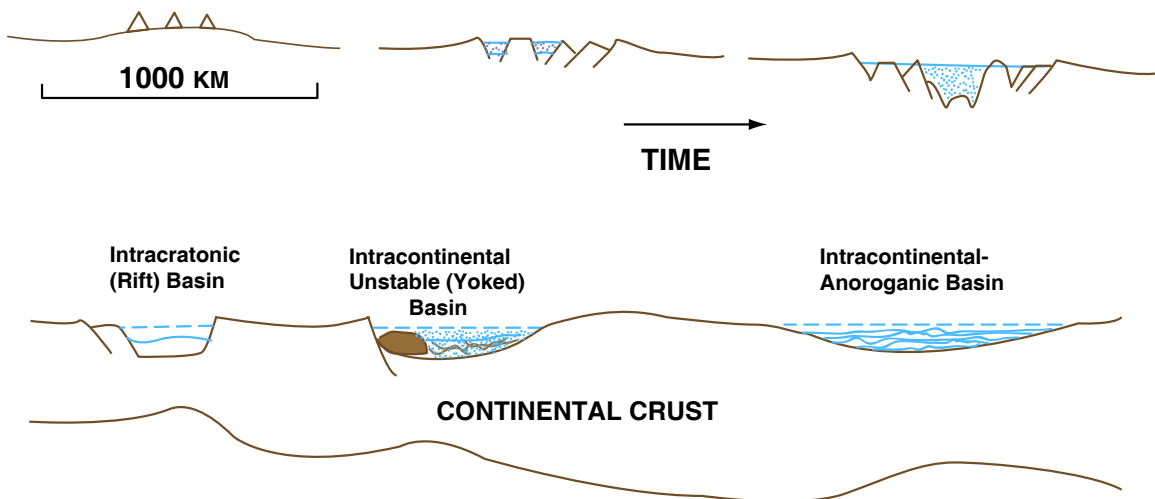
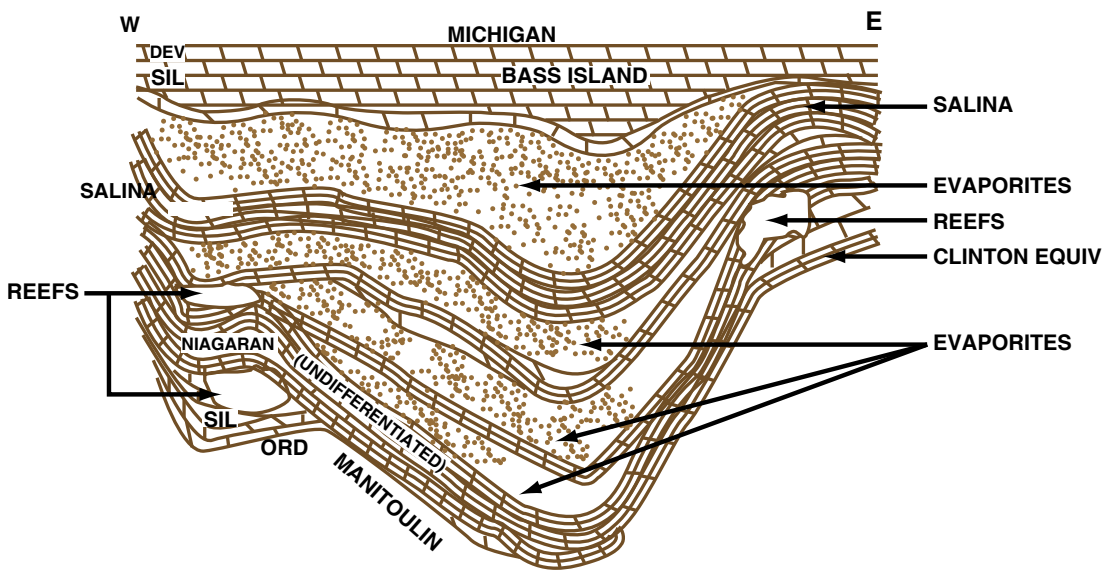
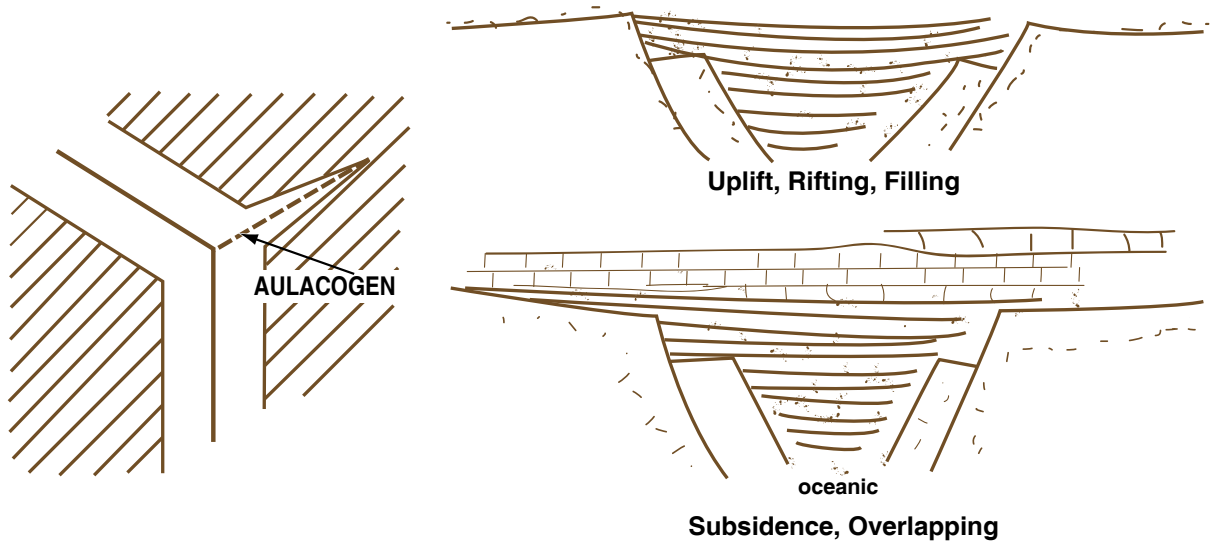


Figure by MIT OCW.

Figure 11-5

tectonic and sedimentary processes: These basins have no apparent connection with plate tectonics. They are thought to reflect very slow thermal subsidence (for times of the order of a hundred million years) after a heating event under the continental lithosphere. But the reasons for depression below the original crustal level are not understood. Erosion during the thermal uplift seems untenable, as does lithospheric stretching. Was the lithosphere made more dense in the area under the basin? Was the lithosphere thinned by “erosion” from beneath? Whatever the reason, the subsequent subsidence can be modeled very well by cooling and isostatic adjustment.

Subsidence is so slow that there seems to have been no depression of the upper surface of the lithosphere, so depositional environments are mostly the same as those in surrounding areas; the succession is just thicker. These successions are also more complete, however—there are fewer and smaller diastems—so at times the basin must have remained under water while surrounding areas were emergent. (A *diastem* is a brief interruption in sedimentation, with little or no erosion before sedimentation resumes.)

size, shape: rounded, equidimensional, hundreds of kilometers across.

sediment fill: shallow-water cratonal sediments (carbonates, shales, sandstones), thicker and more complete than in adjacent areas of the craton but still relatively thin, hundreds of meters.

8.3 Aulacogens

location and tectonic setting: extending from the margins toward the interiors of cratons (Figure 11-5).

tectonic and sedimentary processes: Aulacogens are thought to represent the third, failed arm of a three-armed rift, two of whose arms continued to open to form an ocean basin. In modern settings, aulacogens end at the passive continental margin. An example is the Benue Trough, underlying the Congo River Basin in West Africa. The ocean eventually closes to form an orogenic belt, so in ancient settings aulacogens end at an orogenic belt; an example is the basin filled by the Pahrump Group (Proterozoic) in Nevada and California.

size, shape: long, narrow, linear; tens of kilometers wide, many hundreds of kilometers long

sediment fill: very thick (up to several thousand meters); coarse to fine siliciclastics, mostly coarse, minor carbonates; mostly nonmarine, some marine; contemporaneous folding and faulting; the succession often passes upward, with or without major unconformity, into thinner and more widespread shallow-marine cratonal siliciclastics and carbonates.

8.4 *Rift Basins*

location and tectonic setting: within continental lithosphere on cratons (Figure 11-5).

tectonic and sedimentary processes: Lithospheric extension on a craton, presumably by regional sublithospheric heating, causes major rifts. Some such rifts continue to open and eventually become ocean basins floored by oceanic rather than continental crust; the basin description here then applies to this earliest stage of the rifting. In other cases, the rifts fail to open fully into ocean basins (perhaps some adjacent and parallel rift becomes the master rift), so they remain floored by thinned continental crust rather than new oceanic crust. (Keep in mind that we may be doing too much lumping here.) A modern example: the East African rift valleys. An ancient example: the Triassic–Jurassic Connecticut and Newark basins in eastern North America.

Sediment supply from the adjacent highlands of the uplifted fault blocks is usually abundant, although in the East African rifts the land slope is away from the rim of the highlands, and surprisingly little sediment reaches the rift basins.

size, shape: long, narrow, linear; tens of kilometers wide, up to a few thousand kilometers long

sediment fill: Coarse to fine siliciclastics, usually nonmarine; often lacustrine sediments; interbedded basalts

8.5 Oceanic Rift Basins

location and tectonic setting: In a narrow and newly opening ocean (Figure 11-6).

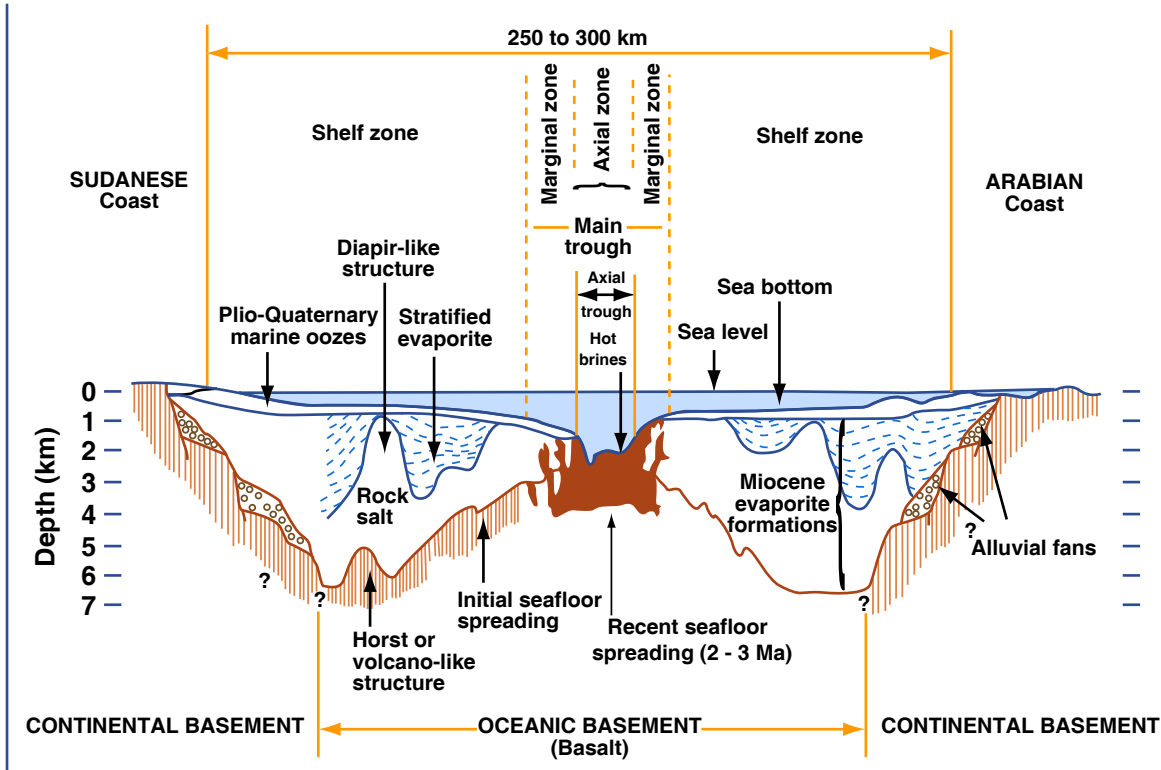


Figure by MIT OCW.

Figure 11-6(a)

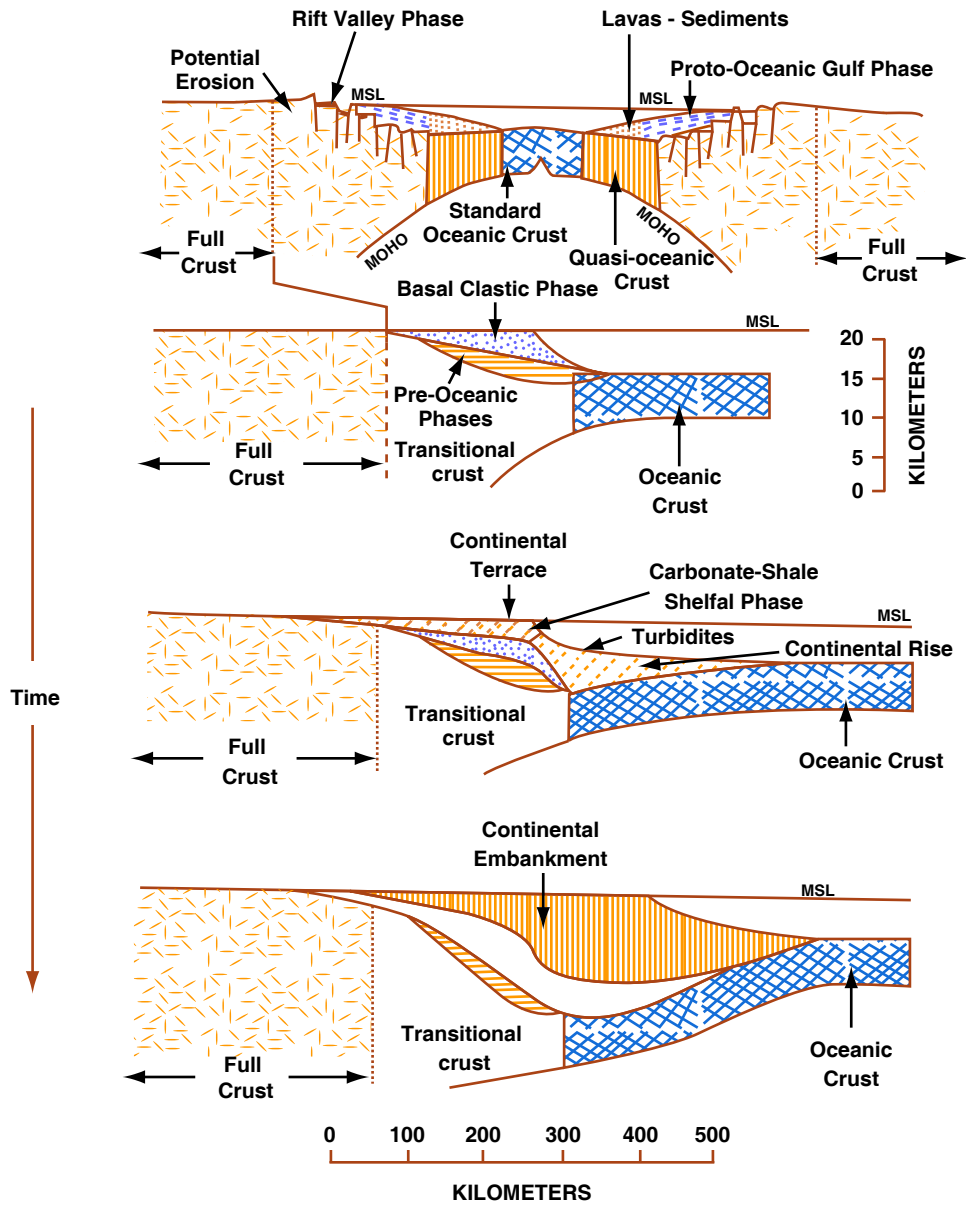


Figure by MIT OCW.

Figure 11-6(b)

processes: This category of basins is transitional between intracontinental rift basins, described above, and passive-margin basins, described below. Basins described here have opened wide enough to begin to be flooded with oceanic crust but are still so narrow that the environment is either still nonmarine or, if marine, has restricted circulation. Modern examples are the Red Sea and the Gulf of Aden. In the ancient, the sediment fill of such a basin is likely to underlie passive-margin sediments deposited later in the history of ocean opening.

size, shape: long, narrow; straight or piecewise straight; tens to a few hundreds of kilometers wide, up to a few thousand kilometers long.

sediment fill: mafic volcanics and coarse to fine nonmarine siliciclastics, as in intracratonic rift basins described above, passing upward and laterally into evaporites, lacustrine deposits, and fine marine sediments, often metal-rich from hydrothermal activity at the spreading ridge.

8.6 Passive Margin Basins

location and tectonic setting: Along passive continental margins, approximately over the transition from continental to oceanic crust formed by rifting and opening of a full-scale ocean basin (Figures 11-6, 11-7).

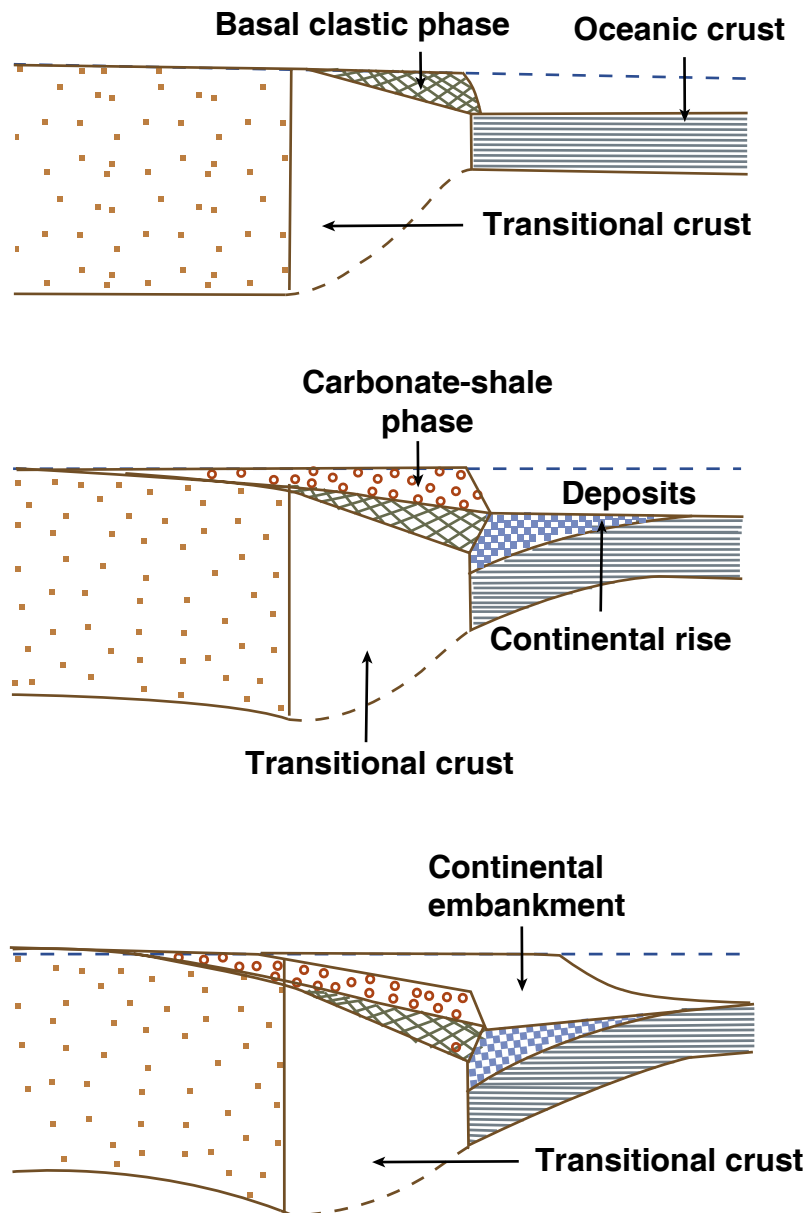
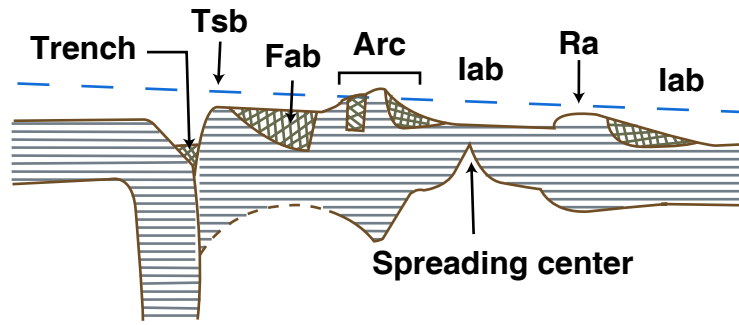


Figure by MIT OCW.

Figure 11-7(a)

Intra-oceanic arc



Continental-margin arc

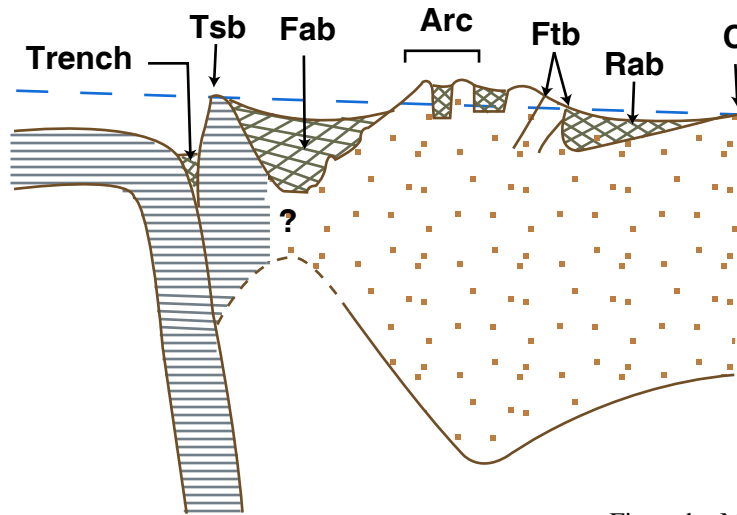
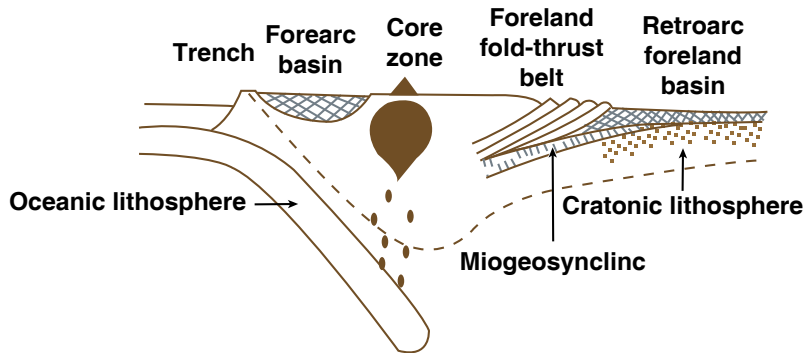


Figure by MIT OCW.

Figure 11-7(b)

RETRO-ARC FORELAND BASIN



PERIPHERAL FORELAND BASIN

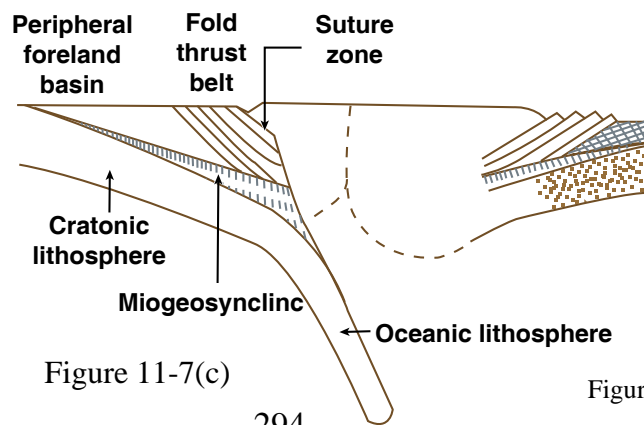


Figure 11-7(c)

Figure by MIT OCW.

processes: As an ocean basin opens by spreading, the zone of heating and extensional thinning of continental crust on either side of the ocean basin subsides slowly by cooling. Sediments, either siliciclastics derived from land or carbonates generated in place, cover this subsiding transition from continental crust to oceanic crust with a wedge of sediment to build what we see today as the continental shelf and slope. In the context of the ancient, this represents the miogeocline. The subsidence is accentuated by loading of the deposited sediments, resulting in a prominent downbowing of the continental margin. Deposition itself therefore does not take place in a basinal geometry, but the base of the deposit is distinctively concave upward.

size, shape: Straight to piecewise straight, often with considerable irregularity in detail; a few hundreds of kilometers wide, thousands of kilometers long.

sediment fill: Overlying and overlapping the earlier deposits laid down earlier during rifting and initial opening are extensive shallow-marine siliciclastics and carbonates of the continental shelf, thickening seaward. These sediments pass gradually or abruptly into deeper marine fine sediments of the continental slope and rise, often grading or interfingering seaward into deep-marine coarse and fine siliciclastics or resedimented carbonates in the form of turbidites building submarine fans at the base of the slope and filling the deepest parts of the ocean basin to form abyssal plains.

8.7 Trenches

location and tectonic setting: In the abyssal ocean, at the line of initial downbending of the subducted oceanic-crust plate in a subduction zone (Figures 11-7, 11-8).

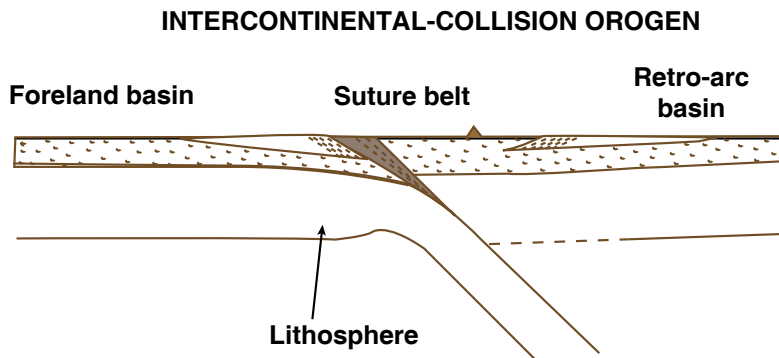
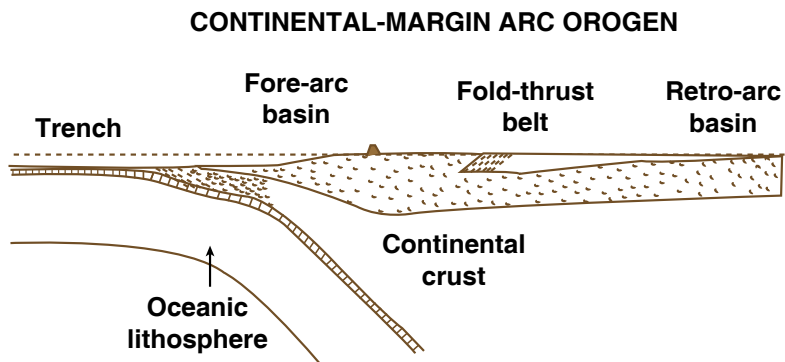
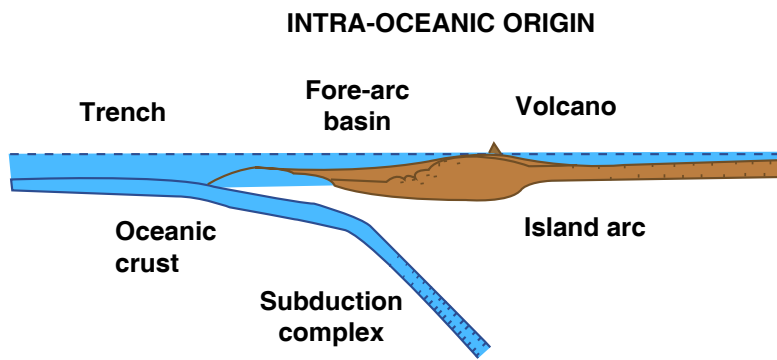


Figure by MIT OCW.

Figure 11-8(a)

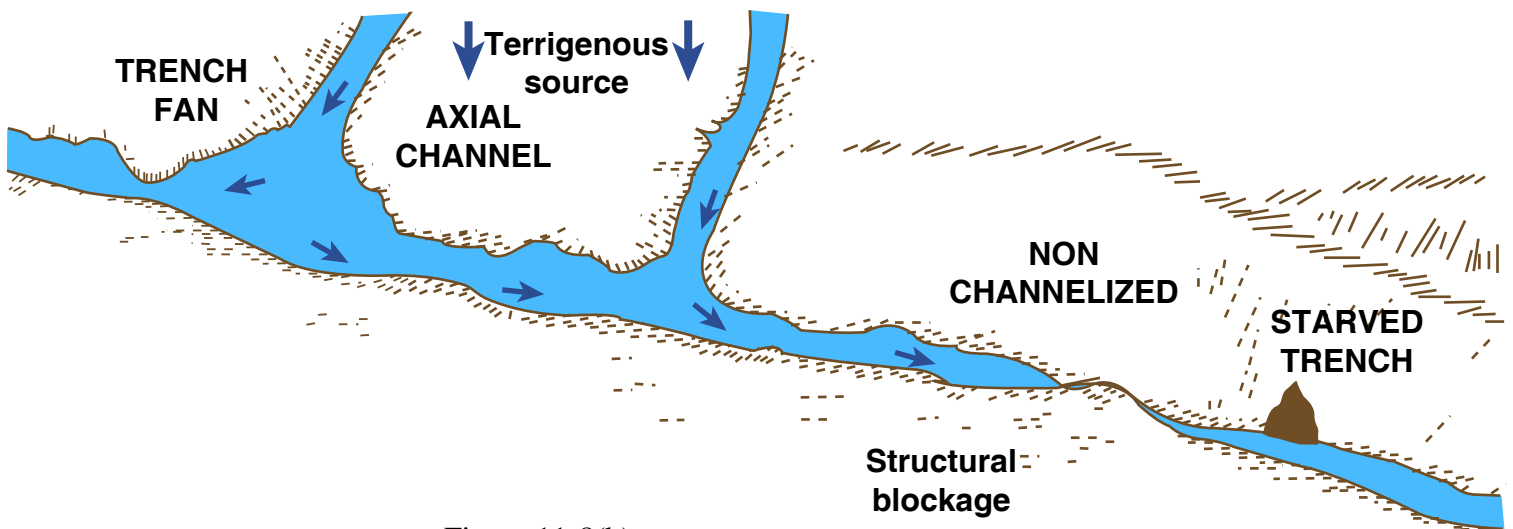


Figure 11-8(b)

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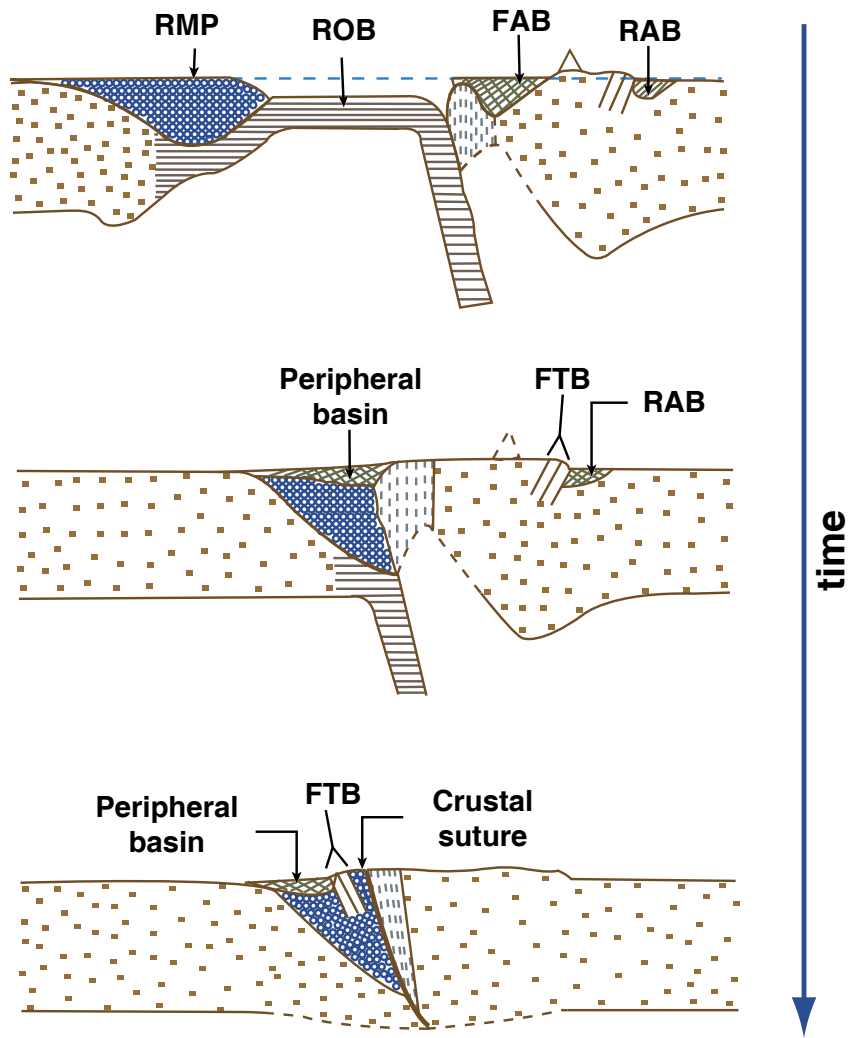


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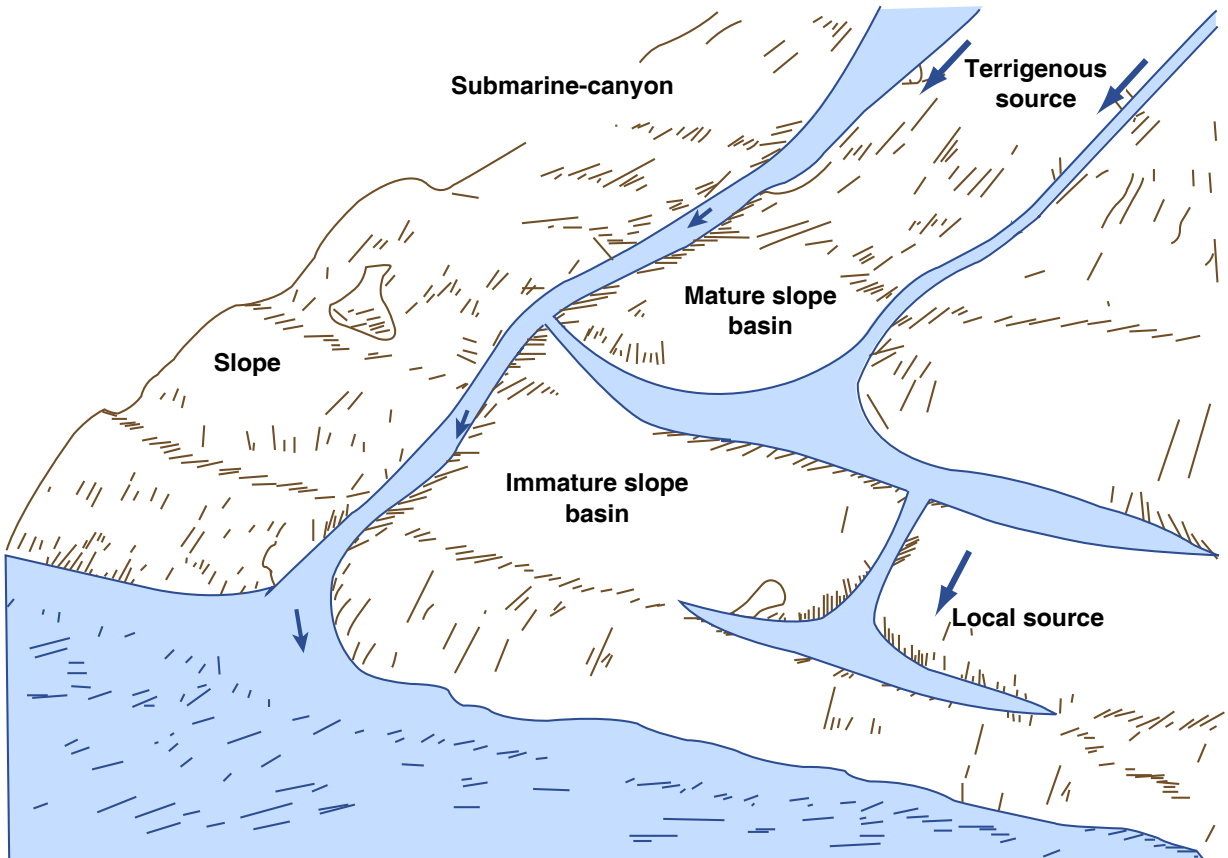


Figure 11-8(d)

Figure by MIT OCW.

tectonic and sedimentary processes: (1) Open-ocean pelagic sediments (mainly abyssal brown clay and organic oozes) are conveyor-belted to the trench, and underlie the sediments, thin to thick, deposited in the trench itself. (2) What happens to the sediments delivered to or deposited in the trench? While still within the trench they are little deformed, but they don't stay that way long. They are either scraped off the descending plate to form an *accretionary wedge*, whose structure ranges from chaotically mixed material in a *subduction mélange* to a fairly regular imbricated succession of underthrust *sheets* dipping toward the arc (note: the thrust sheets themselves get younger downward, but within a given plate the sediments get younger upward), or they are dragged down the subduction zone. The extent of the latter process is controversial, but cases have been described.

size, shape: long and narrow (tens of kilometers wide, thousands of kilometers long), arcuate, with convex side toward the oncoming subducted plate.

sediment fill: varies from thin (hundreds of meters) pelagic sediments (fine abyssal muds, volcanic ash) to thick (thousands of meters) arc-derived coarse siliciclastics and volcanoclastics, as local fans built perpendicular to the trench axis or oblong fanlike bodies built parallel to trench axis.

8.8 Trench-Slope Basins

location and tectonic setting: On the inner (arcward) wall of subduction-zone trenches (Figures 11-7, 11-8).

tectonic and sedimentary processes: The basins are formed as low areas, with closed contours, between adjacent thrust sheets in the growing accretionary wedge. Near-surface folding of sediment in the accretionary wedge may also be a factor in the development of the basins. These basins intercept some of the sediment carried as turbidity currents from upraised older parts of the accretionary complex, or from the more distant arc itself.

size, shape: Small (no larger than kilometers wide, tens of kilometers long, often smaller); linear, and elongated parallel to the trench.

sediment fill: deep-marine silts and muds sedimented directly into the basins or slumped into the basins from higher on the slope; also coarser siliciclastics supplied from farther upslope by turbidity currents.

8.9 Fore-Arc Basins

location and tectonic setting: In subduction zones (Figures 11-7, 11-8); between the upraised subduction complex just inboard of the trench and the volcanic arc (in the case of ocean-ocean subduction) or the overriding continent (in the case of ocean-continent subduction).

processes: As subduction proceeds, a relatively low area, usually below sea level, is formed between the relatively high outer arc upraised by subduction and the inner volcanic arc built by subduction magmatism. Ancient examples of such fore-arc basins are likely to be tectonically isolated from the originally adjacent areas. After an arc-continent collision, another variant of fore-arc basin can be formed between the outer arc and the overriding continent. These basins are likely to be filled mainly from the high land of the tectonically active continent. Later continent-continent collision would make direct reconstruction of their tectonic setting difficult.

size, shape: tens of kilometers to over one hundred kilometers wide, up to thousands of kilometers long; commonly arcuate.

sediment fill: nonmarine siliciclastic fluvial to deltaic deposits at the arcward margin pass seaward into deep marine siliciclastics, mainly sediment-gravity-flow deposits, all interbedded with arc-derived volcanics flows and pyroclastics. Section thickness can be many thousands of meters.

8.10 *Foreland Basins*

location, tectonic setting, processes: There are two kinds of foreland basins: *retro-arc foreland basins*, which are formed on stable continental crust by loading by thrust sheets moving toward the continental interior as a result of compression and crustal shortening in an ocean–continent subduction zone, and *peripheral foreland basins*, formed after continent–continent collisions by loading of the continental crust of the subducted plate by development of thrust sheets in the continental crust of the subducted plate directed back away from the subduction zone (Figures 11-7, 11-8). Both kinds tend to be asymmetrical, with their deepest parts nearest the emplaced thrust sheets. They tend to migrate away from the arc or suture zone with time. They are filled by sediments derived from the mountainous terrain associated with the compression and thrusting.

size, shape: tens to a few hundreds of kilometers wide, hundreds to thousands of kilometers long; often with varying development along their length; commonly arcuate or piecewise arcuate, reflecting the geometry of subduction.

sediment fill: Coarse fluvial siliciclastics, mainly as alluvial fans, thinning and fining away from the arc or suture, often passing into shallow-marine sandstone–shale successions if sea level is high enough to flood the basin. Thicknesses are up to many thousands of meters. The classic *molasse* facies, thick nonmarine conglomerates, is deposited in foreland basins.

8.11 *Remnant Basins*

location and tectonic setting: within suture zones formed by continent–continent collision (Figures 11-8, 11-9).

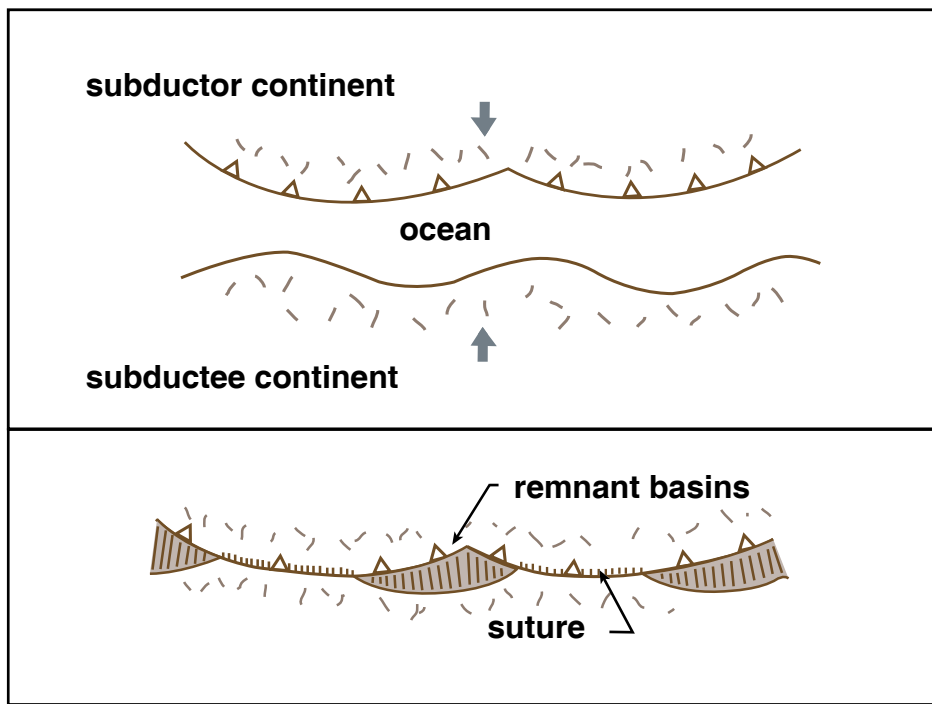


Figure 11-9(a)

Figure by MIT OCW.

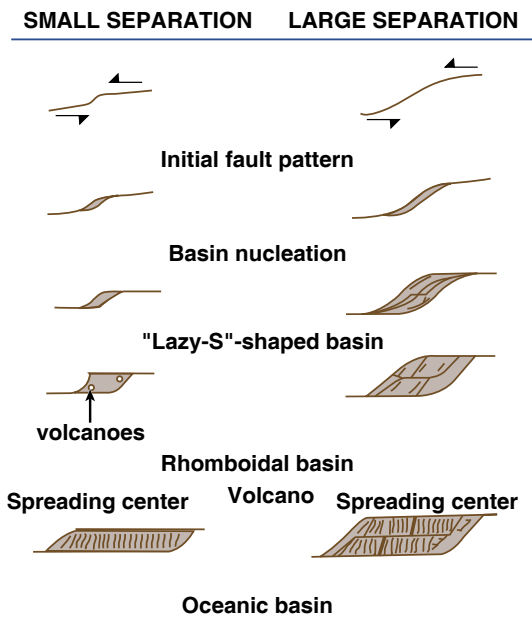


Figure 11-9(b)

Figure by MIT OCW.

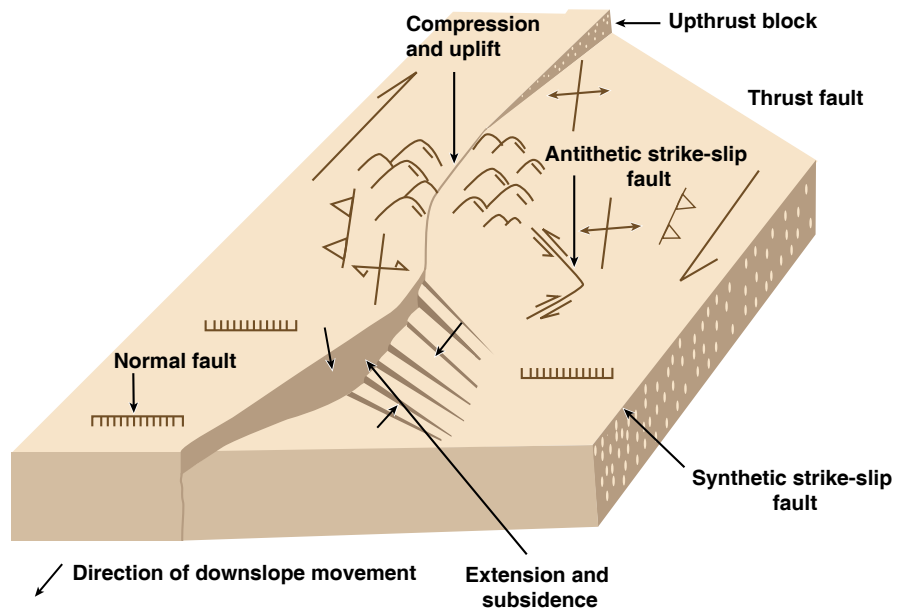


Figure 11-9(c)

Figure by MIT OCW.

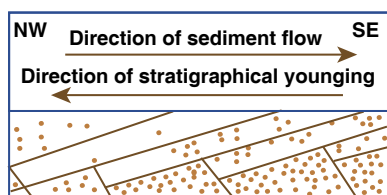
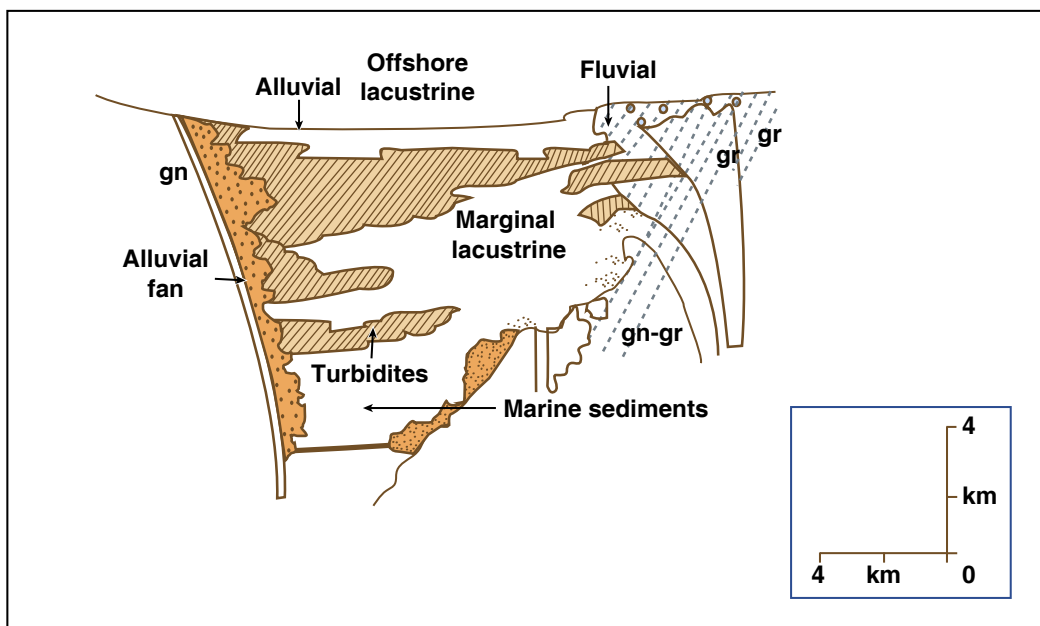


Figure by MIT OCW.

Figure 11-9(d)

processes: Continental margins and subduction zones are (for different reasons, connected with geometry of rifting and geometry of subduction) commonly irregular in plan rather than straight, so when continent–continent collision eventually comes to pass, certain salients of continental crust encounter the subduction zone before reentrants. With further subduction and suturing, this creates isolated basins still floored by residual oceanic crust, which receive abundant sediment from adjacent strongly uplifted crust.

size, shape: many tens to hundreds of kilometers across; irregular in shape.

sediment fill: very thick and highly varied, with strong lateral facies changes; usually fluvial at the margins, commonly passing into deep-marine sediment-gravity-flow deposits; sometimes the basin becomes sealed off from the ocean, so that facies include lacustrine sediments.

8.12 Pull-Apart Basins

location and tectonic setting: Locally along major strike-slip or transform faults, either in continental crust or in oceanic crust (Figure 11-9).

processes: If a strike-slip fault is stepped or curved rather than straight, movement along it tends to produce *tension*, where the sense of the curvature and movement are such that the walls of the fault are pulled apart from one another (this kind of regime is described as transtensive), or *compression*,

where the sense of the curvature and movement are such that the walls are pushed against one another (this kind of regime is described as transpressive). In the tensional segments, gaps or basins are produced which are filled with sediment from adjacent high crust.

size, shape: There is a strong tendency for pull-apart basins to be rhomboidal. They range from approximately equidimensional early in their history to elongated later. Widths are kilometers to a few tens of kilometers, and lengths are kilometers to many tens of kilometers. Some basins are even smaller than this.

sediment fill: The continental-crust basins, which are the most significant sedimentologically, are filled by thick nonmarine to marine coarse to fine clastics, often as alluvial fans passing into lake deposits or into deposits of restricted marine environments. In some cases thick marine turbidites fill the distal parts of the basin. There is usually sharp variation in facies laterally, and the thickness of the lithologic units may be not much greater than the lateral extent, or even less. Deposition is concurrent with elongation of the basin, so be wary of total section thickness computed by bed-by-bed measurements of the section.

9. LITERATURE

9.1 Here are some literature sources on sedimentary basins. Some of these are textbooks or monographs, others are collections that are outgrowths of symposia. I haven't listed individual papers on the sedimentology, stratigraphy, tectonics, or geophysics of sedimentary basins, but you can find references to most of them in the sources listed below. These sources thus would provide you an efficient entry into the literature on sedimentary basins.

Ballance, P.F., and Reading, H.G., 1980, Sedimentation in Oblique-Slip Mobile Zones. International Association of Sedimentologists, Special Publication 4, 265 p.

Brenner, R.L., and McHargue, T.R., 1988, Integrative Stratigraphy; Concepts and Applications: Prentice Hall, 419 p.

Dickinson, W.R., ed., 1974, Tectonics and Sedimentation: Society of Economic Paleontologists and Mineralogists, Special Publication 22, 204 p.

Dott, R.H., Jr., and Shaver, R.H., eds., 1974, Modern and Ancient Geosynclinal Sedimentation: Society of Economic Paleontologists and Mineralogists, Special Publication 19, 380 p.

- Hallam, A., 1981, *Facies Interpretation and the Stratigraphic Record*: Freeman, 291 p.
- Leggett, J.K., ed., 1982, *Trench–Forearc Geology; Sedimentation and Tectonics on Modern and Ancient Active Plate Margins*: Geological Society of London, Special Publication 10, 576 p.
- Miall, A.D., 1984, *Principles of Sedimentary Basin Analysis*: Springer, 490 p.
- Mitchell, A.H.G., and Reading, H.G., 1986, *Sedimentation and Tectonics*, *in* Reading, H.G., ed., *Sedimentary Environments and Facies*, Second Edition: Blackwell, p. 471-519.
- Potter, P.E., and Pettijohn, F.J., 1977, *Paleocurrents and Basin Analysis*, Second Edition: Springer, 425 p.