Sedimentary structures and bedding planes (Mazzullo and Graham, 1988)

Internal sedimentary structures

The internal (cross-sectional) sedimentary structures that are exposed on the surface of a core can be described using the following terms:

1. **Normal graded** describes a bed that exhibits a gradual upward decrease in grain size.
2. **Reverse graded** describes a bed that exhibits a gradual upward increase in grain size.
3. **Laminated** describes a bed that contains thin (<1 cm) horizontal or inclined beds (laminae) with no internal foresets.
   The thickness of the individual laminae can be described by the following terms:
   a. Thickly laminated: laminae >0.3 cm thick.
   b. Thinly laminated: laminae <0.3 cm thick.
   The geometry of individual laminae can be described by the following terms:
   a. Planar laminated: the laminae are bounded by parallel and planar bedding planes and are continuous in thickness across the width of the core;
   b. Wavy laminated: the laminae are bounded by one or two wavy and parallel bedding planes and are continuous but variable in thickness across the width of the core;
   c. Wedge-planar laminated: the laminae are bounded by nonparallel and planar bedding planes and pinch out in one direction across the width of the core; and
   d. Lenticular: the laminae are bounded by one or two wavy and nonparallel bedding planes and pinch out in two directions across the width of the core.
   Lamination of fine sediments is generally the result of slight changes in texture or composition that may be due to organic action (as in stromatolites) or to variations in current velocity and turbulence, sediment supply, or climate (as in varves or muddy turbidites). Lamination of coarser grained (sand and gravel) sediment is generally the result of upper flat-bed flow, sheet flow, or wind-ripple migration (e.g., Harms et al., 1982).

4. **Cross-laminated** describes a bed that contains thin horizontal or inclined laminae <1 cm in thickness with inclined internal foresets. The thickness of the individual laminae can be described as thickly or thinly laminated and their geometry as planar, wavy, wedge-planar, or lenticular (see above). Cross-lamination is generally the product of ripple migration. The type of cross-laminations can be described by the following terms:
   a. Tabular: the foresets are planar and parallel and intersect the lower bedding plane at an angle; and
   b. Trough: the foresets are curved and parallel and intersect the lower bedding plane tangentially.
5. **Cross-stratified** (or cross-bedded) describes a bed that contains inclined internal foresets (and possibly subhorizontal topsets and bottomsets) >1 cm in thickness. The cross-bedding may be described as either tabular or trough cross-bedded, using the same criteria that are described for cross-laminated sediments. Cross-bedding is generally a product of dune (sand wave and megaripple) migration.
6. **Flaser-bedded** describes a bed that contains thin horizontal or inclined laminae with inclined internal foresets and thin (<l cm) lenses of another sediment type within their troughs. Flaser beds are generally the products of variations in current energy (e.g., flaser-bedded tidal sand and mud or turbidite silt-mud units); the lenses are commonly fine-grained sediment that accumulates in the troughs of ripples during low-energy periods.
7. **Convoluted** describes a single bed whose internal laminations have been intricately folded. The folding does not generally extend to the bedding planes or into adjacent beds. Convoluted beds or slump folds are generally gravity-induced soft-sediment deformation structures and are most common to sand and silt.
8. **Water-escape pipes** (fluid-escape structures) are features produced by the escape of fluids from a bed after deposition, including "dish," "pillar," and "vertical sheet" structures.
9. **Microfaulted** describes a single bed whose internal lamination has been disrupted and vertically displaced by microfaults. The faults do not generally extend to the bedding planes or into adjacent beds. They are gravity-induced soft-sediment deformation structures and are common to beds that are deposited on high slopes (e.g., dune avalanche faces).
10. **Fractured** describes a bed that is naturally fractured or jointed along planes that extend through its bedding planes and into adjacent beds. The fracture may be empty or partly or completely filled by authigenic minerals.
11. **Concretions** are localized pore-filling cementation of the host sediment. Common cement minerals in concretions are calcite, dolomite, gypsum, pyrite, barite, and zeolites. Many concretions are ovoid, but they may also display a wide range of shapes.
12. **Nodular** describes a bed that contains discrete masses of a distinct and discrete mineralogy. Nodules are generally formed by syn- or postdepositional precipitation or recrystallization of microquartz, pyrite, halite, anhydrite, gypsum, phosphorites, calcite, manganese, and other minerals on the surface of or within the sediment. Nodules contrast from concretions by having a completely distinct mineralogy from the surrounding sediment (i.e., few or no granular components).
13. **Nodular mosaic** describes a bed that contains coalesced nodules of chemical minerals. Nodular-mosaic beds are commonly formed by the syndepositional precipitation of evaporites within a bed. The nodules grow within and eventually displace and

replace the original sediment in the bed and merge to form sutured contacts. Remnants of the original sediment are commonly present within and between the nodules.

14. **Vuggy** describes a bed with large cavities or pores ("vugs"). The vugs are commonly formed by shrinkage (as in birdseye limestone), dissolution (as in moldic pores or true vugs), bioturbation (as in borings), and framework growth (as in reefs), and may be partly or completely filled with detritus or authigenic minerals. Vugs may also be left by evaporation of methane hydrates.
15. **Slightly bioturbated** describes a bed that has been partially disturbed by bioturbation. Trace fossils from burrowing organisms are present and perhaps abundant on the exposed surface of the bed (and should be described), but the bed's primary depositional stratification is still apparent.
16. **Heavily bioturbated** describes a bed whose original stratification has been highly or completely disturbed by bioturbation.
17. **Massive** or **structureless** describes a bed that is homogeneous in lithology and color and exhibits no bedding, cross-bedding, grading, bioturbation, or bed disturbance. Massive beds are the products of rapid sedimentation, grain-flow deposition, or bioturbation but show no evidence of their origins. They are also common to coarse sand and gravel deposits, as well as to supermature sediments.
18. **Fossiliferous** describes a bed containing one or more macrofossils. The fossil types should be identified, if possible.
19. Pebbles, cobbles, and mud clasts should be identified when they occur isolated in a section; for example, glacial dropstones and rip-up mud clasts.

Bedding Planes

A description of the sedimentary structures of a bed should also include a description of the types of bedding planes and, if observable, any structures or markings upon them (surface and sole marks). A bedding plane can be described as sharp or gradational and planar or wavy; the surface and sole marks can be described by the following terms:

1. **Scours**: sharp, wavy lower bedding planes that clearly truncate underlying beds.
2. **Load marks**: small knobby depressions on an upper bedding plane (with corresponding load casts on the underside of the overlying bed) that are formed by the sinking of a more dense sediment into a less dense sediment.
3. **Desiccation cracks**: downward-tapering v-shaped fractures on an upper bedding plane.
4. **Ripple marks**: wavy upper bedding plane formed by symmetrical or asymmetrical ripple crests.