Cross stratification

Neither the text nor the lab manual give a very clear description of why and how different types of cross stratification occur, so I will attempt to do so here.

Cross stratification forms under laminar flow conditions, either in water (rivers, deltas, beaches) or in air (sand dunes). They can form with uni-directional flow (eg. rivers), or bi-directional flow (eg. waves on beaches, tidal flows, winds that change directions). Figure 4.4A in the text gives a clear picture of the velocity patterns which cause cross stratification to form. As water or air flows into the lee side (downflow side) of an object it slows down, and some of the sediment that was in suspension will settle out. Cross stratification starts to occur when there are some imperfections already existing on the surface.

Cross beds always dip down in the direction towards which the water or air was flowing. (////// ← flow) If ripples are evident on the surface of the sediment (or a bed in sedimentary rock), it commonly follows that some cross stratification will be present

Where the set height is less than 6 cm (and the cross-stratification layers are only a few mm) the term **cross lamination** is used. For larger features the term **cross bedding** is used. In fact the generic term that is used most commonly is cross bedding (as opposed to cross stratification).

The slope of the foreset beds will be a function of the grain size of the sediments. Coarse (sand and gravel) sediments will give steep slopes, while fine sediments (fine sand and silt) will give shallow slopes. In many cases the cross bed angles will shallow in the down-flow direction, giving a tangential contact with the underlying bed. These nearly tangential parts are called bottom sets.

Cross beds are described as **trough** or **planar** based on their shape along a cross-section perpendicular to the flow direction. (See the upper figure on the 3rd page of Lab 5.)

Some different cross-bed features are illustrated on Figure 4.5.

> If the flowing medium is shallow (ie. very shallow stream water) cross beds do not form (4.5A).
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> If the water is deep enough and velocity is low, or grain-size large, trough cross beds will form (4.5B).
>
> If velocity increases, or grain size decreases tabular cross beds will form (4.5D).

If there is an abundant supply of sediment, and hence net accumulation of sediment, climbing ripples will form. The diagnostic feature of climbing ripples is that some of the undulating surface of one set of ripples is preserved when the next layer of ripples is deposited on top (so that the boundaries between sets of cross beds are not planar). (4.5G and H). (The more common situation, in which sediment supply is restricted and the existing ripples are partly eroded during formation of an overlying layer of ripples, results in **truncated** cross bedding.)

If the flow becomes turbulent, neither ripples nor cross-beds will form.

With bi-directional currents different layers of the cross stratification will dip in different directions (4.5E and F). Tidal flows typically form herringbone cross laminations (Figure 4.7).

Where both sand and mud sized material are present in the depositional environment (eg. in tidal regions), lenticular, wavy or flaser bedding may form along with the cross beds (see Figure 4.9). Lenticular bedding is mud-dominated. Flaser bedding is sand-dominated.