G528 – 2005
Paleocurrent Analysis Lab:

In this lab, you will be introduced to the acquisition of paleocurrent measurements in sedimentary rocks and will spend some time learning how to restore paleocurrent data of various forms to their original directions.

First, you will need to acquire your data – in this section, I describe the basics of paleocurrent data acquisition. You should be familiar with these techniques in general. For the purposes of this lab, you will be given paleocurrent data.

1) Introduction:
Paleocurrent indicators are oriented sedimentary structures interpreted to have been deposited by ancient flows. Cross-beds slip faces, pebble imbrication, parting lineation, tool marks and groove casts, and ripple crest orientation are all examples of possible paleocurrent indicators. Some paleocurrent indicators are unidirectional – that is, their shape provides unique information about the direction of the ancient paleoflow. Unidirectional paleocurrent indicators include foresets (ripple or dune), flute casts, and clast imbrication. Some paleocurrent indicators are bidirectional – that is, their shape eliminates all but two possible directions (either upcurrent or downcurrent). Bidirectional paleocurrent indicators include oriented wood fragments or other elongates clasts, tool marks or elongate sole marks, and parting lineation. Commonly, however, paleocurrent measurements are acquired from deformed (i.e. tilted) beds, so the beds and paleocurrent measurements must be restored to paleohorizontal before the directions of paleoflow can be meaningfully interpreted. This may be accomplished manually through stereonet rotation, or it may be done using a computer. In this lab, you will utilize a computer program to interpret your data.

For a more detailed introduction to paleocurrent analysis, check out the G528 website, paleocurrents lecture.

2) Measuring paleocurrent data in the field:
The orientation of paleocurrent indicators can be easily measured in the field with a brunton compass or other simple measuring device. For planar paleocurrent indicators (cross-beds, pebble-cobble imbrication planes), the strike and dip of the planar feature is measured. The dip direction in cross beds is the paleoflow direction. In pebble and cobble imbrication, the dip direction of the long-intermediate axis of the pebbles is upstream, because flat clasts are in their hydrodynamically most stable position if they are leaning downstream (see sketch above), For sinuous-crested ripples and dunes, a complication arises in that the trough limbs don't dip downstream but rather dip at a high angle to paleoflow direction. However, the trough axis dip direction is parallel to the paleoflow direction, and trough limb orientation information can be statistically treated to obtain a vector average of the paleoflow direction. For a good discussion of these statistical techniques, check out the following paper:

DeCelles, P.G., Langford, R. P., and Schwartz, R. K., 1983, Two methods of paleocurrent determination from trough-stratification: Journal of Sedimentary Petrology, v. 53, p. 629-642.

For linear paleocurrent indicators, the long-axis of the indicator is usually assumed to be parallel to flow direction. This is the case with elongate clasts that are entrained in a flow. A complication arises with linear indicators that “roll” and are oriented with their long axis perpendicular to flow. It’s important to recognize this difference in the field.

If the feature is planar, you will need to measure both strike and dip of the plane; if the feature is linear (e.g. oriented wood fragments), you will need to measure the trend and plunge OR the pitch angle, sign, and ‘observation orientation’ (i.e. whether you are reporting data as though looking down on the top of the bed or up from the bottom of the bed). ***Be sure in either case to acquire a separate measurement for the bedding attitude.***

Note: Although we will not collect field paleocurrent data as formal part of this lab, we will certainly do so during the midterm exam field trip on October 8. Therefore, you should be familiar with the basic techniques described above. If you are unfamiliar (or rusty) with the use of a compass to measure planar and/or linear features, please take a few minutes to refresh yourself or ask for a demonstration.

2) Restoration of cross-bed data: Using the Macintosh computers in room SC110, launch the Stereonet program. It is located in the G528 folder under ‘Paleocurrent lab’. In the file marked Tabxsets.raw you have been given 30 strike and dip measurements of tabular cross bed slip facies. Open the file from within the Stereonet program and view its contents by pulling down *List Current Contents* under the **Data** header. You should see 30 strike and dip measurements. (You will have to hit a carriage return -- CR -- to view the tail end of the data set.) These data were collected in China in 1989 by measuring the strike and dip orientations on tabular foresets from a Jurassic braided river deposit. Note the very steep dips of the slip faces (most are >80°). The steep dips result from tilting of the entire outcrop, including the paleocurrents, in the direction of paleoflow to produce oversteepened slipfaces. Since the orientations of slip faces in the outcrop reflects both the original paleoflow direction as well as post-depositional tilting of the section, it is critical that the outcrop (including the paleocurrent measurements) be restored to paleohorizontal prior to their interpretation. To do this, you will need the strike and dip of the bedding within that outcrop. It is 83 / 82SE.

Now that you have the raw data loaded into the program and you know the bedding strike and dip, you are ready to perform the rotation and plot the results. To do this, go to the **Operations** header and pull down *Rotate Data*. You will be given a variety of options. Since you have measured a set of planar features (slip faces), you must select planes. Next you must enter the directions and values of rotation. This is simple but involves some thought. The first of the three options asks for the azimuth of rotation. You want to restore your entire outcrop to horizontal. To do this, you must rotate about a strike line. Thus, for this value of the azimuth of rotation, you enter the line of strike for your outcrop, in this case 83°. Since the strike line is, by definition, horizontal, you enter 0° for the plunge of the rotational axis. If you collected your data in one limb of a plunging fold, and you knew the value of plunge, you would enter it here. Now comes the tricky part. The dialog box says ‘A positive angle is clockwise looking in the direction of the given axis.’ You have entered the azimuth of the axis of rotation as 83 degrees. Thus, ‘looking’ in that direction (i.e. east-north-east), you want to rotate your beds counterclockwise to restore them to horizontal. If you restore them in a clockwise direction (i.e.

positive, looking in the direction of the given azimuth of rotation), you will not restore your beds to horizontal but will instead overturn your beds. Thus you must enter -82° for the magnitude of rotation to restore your beds and paleocurrent measurements to horizontal. Alternatively, you could enter the azimuth of rotation as 83+180=263° and then enter 82° (positive) as the magnitude of rotation. This aspect of using this program is tricky, though pretty simple once you think through it. It's always best to visualize what you're doing mentally or with your hands, etc.

Now that you have rotated your planes, you need to calculate the poles to those planes before they can be plotted up on a rose diagram. This is the case for any planar paleocurrent data you may be dealing with (e.g. cross bed slip faces, imbrications, etc.). To calculate poles from planes, go back to the **Operations** header and pull down *Poles*.

The Stereonet program you are using calculates projected poles on a lower hemisphere (not an upper hemisphere) surface. Projection of these cross-bed poles on a lower hemisphere projection will result in a plot that is precisely 180° incorrect (i.e. the poles will be showing transport opposite to that reflected by the orientation of the measured cross-beds). To orient the poles so that they will plot "correctly", it is necessary to rotate them by 180° prior to plotting them on the lower hemisphere projection. This can easily be accomplished by rotating your poles (not the planes which the program still has in its memory) by 180° about a vertical axis. To do this, go back to Operations and select *Poles* (since that's what you want to rotate), then select 0° for the azimuth of rotation and 90° for the plunge of the rotation axis. Input 180° for the magnitude of rotation.

To plot your data, go to **Plot** and select *Rose Diagram*. The dialog box will ask whether you want to plot planes or lines. The data you want to plot are your corrected, rotated poles from your original data, not the corrected planes (which are still in the program's memory). So, you want to select 'lines'. The program will then ask you to enter a value for the outer perimeter of the diagram between some number and 100. Select the small number to get the biggest (and most easily interpreted) plot. After doing this, your Rose Diagram should appear. If you have done everything correctly, your plot should show the paleocurrent direction to be to the south-southwest with a few scattered points to the northeast and elsewhere. Print this plot out and label it. Be sure to include in the label the paleocurrent indicator type, some idea as to the field location, and the number of measurements included in the plot.).

3) Pebble Imbrication data. Pebble imbrication data are dealt with in the same manner as with slip-face data, except there is no need to rotate the poles you calculate from your rotated planes about a vertical axis prior to plotting them. This is because imbrication planes dip up-current, whereas slip faces dip down-current. Calculating poles from up-current-dipping paleocurrent indicators and plotting those poles on a lower hemisphere projection surface results in a correctly oriented plot.

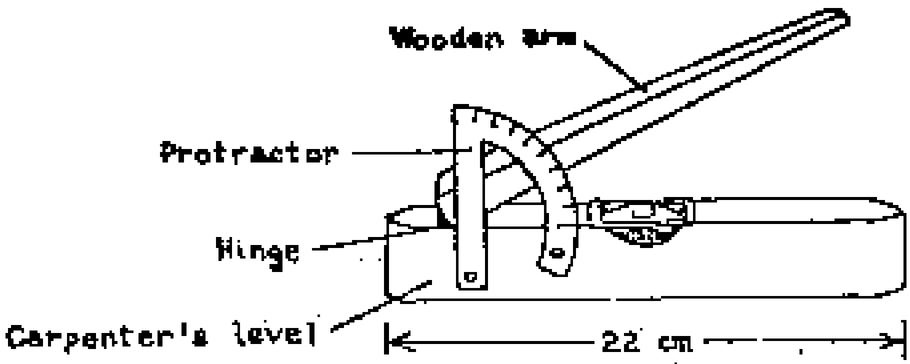
In the file marked Imbrication1.raw you will find a set of imbrication data, also collected from China in 1989. The bedding plane strike and dip is 85 / 49 NW. Restore your data to paleo-horizontal, calculate the poles from your restored planes, and plot up the rose diagram. You should have a bi-directional spread of corrected data with one mode indicating east-northeast transport and one indicating west-northwest transport. Print out your final plot or copy the plot to diskette and hand it in with your lab.

4) Now you're ready to restore some linear paleocurrent data such as you might collect from oriented plant fragments, parting lineation, tool marks, groove casts, flute casts, etc. Linear features require a somewhat different, though simpler, method of restoration than that of linear features discussed above, provided the field data were acquired in the correct manner. If field measurements of linear features were collected in the form of bearings and plunges, then you should rotate the bearing and plunge of the feature about the strike line (azimuth of rotation) using the bedding dip as the amount of rotation. This procedure is somewhat cumbersome, however, and it can be difficult to obtain accurate bearing and plunge measurements in the field. It is much easier to obtain field data on linear features in the form of the angle of pitch formed between the strike line and the linear paleocurrent indicator. Pitch angles can be easily measured using a simple device consisting of 2 adjustable arms, one of which is equipped with a level bubble (see illustration below). A protractor is mounted between the arms, allowing the angle formed between them to be measured. The arm with the level is used to define the strike line, by definition horizontal, and the other arm is oriented such that it is parallel to the paleocurrent indicator. *The device must be held parallel to the bedding plane or bedding sole in order to obtain the correct pitch measurement*. Care must be taken to indicate whether the angle is positive (clockwise) or negative (counterclockwise), whether it is measured from the strike line to the paleocurrent indicator or verse vice, and whether it is measured on a bedding plane (looking down stratigraphically) or on a bedding sole (looking up stratigraphically). I conventionally measure pitch angles looking stratigraphically downsection, measuring from the strike line to the linear indicator (e.g. pitch angle is 45° counterclockwise measured from strike to indicator looking downsection). After the bedding strike and pitch angles have been measured, you simply need to add (or subtract) the pitch from the strike to obtain the restored paleocurrent direction. See the supplementary discussion by Bill Dickinson in your handouts for additional descriptions of this paleocurrent measuring and restoring technique. It is frequently convenient and informative to do this operation in real time in the field. In this laboratory exercise, it is best to enter the corrected linear orientations into a file, using a calculator to do the additions or subtractions. After the corrected features have been entered, you can simply plot them on a rose diagram. Do this, and hand in your labeled plot with your lab. Below are a series of measured pitch angles for parting lineation in a series of sandstone beds. The bedding strike is 66°, and the dip is 51 NW.

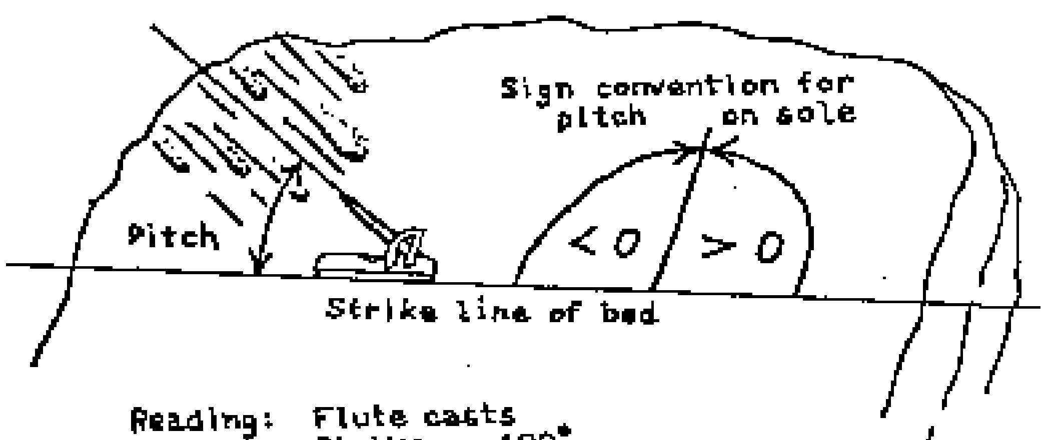
15°	clockwise,	strike to indicator,	looking downsection
24°	"	"	"
24°	"	"	"
23°	"	"	"
23°	"	"	"
22°	"	"	"

Turn in all materials at class time by Wednesday September 28.

INSTRUMENT FOR MEASURING PITCH:



MEASURING PITCH OF SOLE MARK:



Reading: Flute casts
Strike : 100°
Pitch : – 35°
Sense : to SW

Restored azimuth = 100 + (– 35) = 65°
(Down-current azimuth = 245°)

Fig. 4. Instrument and technique for measuring pitch.