VARVE MEASUREMENT AND ANALYSIS PROGRAMS –OPERATION INSTRUCTIONS

USING THE COUPLET MEASUREMENT UTILITY (Varve300.itm)

1. Starting Image Tool and Couplet Measurement

Start Image Tool 3.0 by double clicking the $IT_{3.0}$ icon on your desktop. (To install the IT3.0 icon on your desktop see the varve program setup instructions in the supplemental material). After starting Image Tool, the couplet measurement routine can be found in the "Processing" pull-down menu under "Varve". If Varve300.itm has been installed properly there will be a choice called "Couplet measurement", which will start the measurement program.

Note: Hint boxes provide useful instructions and prompt you for actions as you proceed through the whole measurement routine. The boxes can be moved to convenient places on your screen during analysis. We don't recommend that you minimize Image Tool or use other programs on your computer while measuring varves. When using the script programs Image Tool has been known to lose track of its progress, possibly due to stray mouse clicks outside the image being analyzed that it does not know how to interpret.

2. Loading a Set of Varve Images

The measurement routine begins by loading a set of varve images for measurement from the RAWVRV sub-folder in IMAGES. (see the Format of Images section above). If you downloaded the IMAGES folder to your computer there is a set of practice images in the RAWVRV sub-folder named: PRAC1-1, PRAC1-2, PRAC1-3, and PRAC1-4. A series of questions will lead you through the procedures for loading images for measurement. For the practice set use the following parameters.
The core set to open is: PRAC1
They are Jpeg images. Choose 2
Starting image: 1
Ending image: 4

You do not have to measure all images in an image set. If you wanted to measure only one image you would choose that image as both the starting and ending image. You can also do part of an image sequence, for example starting with image 2 and ending with image 3. If you do not start with image 1 the program will prompt you for the varve number (integer) of the last varve beneath your 1st measurement. This will start the varve count for the current image as a continuation of previously measured images in the image sequence. You will next be prompted for the starting value of the running total (decimal number), which is the total core thickness up to this point of all varves measured in previous images in the sequence. This allows you to measure parts of cores that have large numbers of images and later cut and paste the data tables together, while having images annotated correctly with varve count numbers and a continuous running total of varve thickness for all images.

3. Opening an Image

When the images are loaded (you will see lots of flashing images) you will be prompted in a box to arrange the images and fully open the 1st image you wish to measure (bottom image, lowest # in the

image sequence you have chosen). You must have this image fully open with no slide bars before attempting the calibration (see caution statement below).

Caution: If you start with another image open or do not have an image fully open in the calibration routine you will not be able to go back and will have to start the whole core set over. Images that are not fully open and have slide bars will also not work when it comes time to measure varves.

4. Image Calibration

When your images are arranged and your 1st image is open it is time to calibrate the 1st image. Hitting **shift** will begin the calibration procedure in which you draw a line of known length, usually in centimeters. All images should be calibrated in the same units. A calibration length can be drawn in any direction on the image. If you accept the calibration you will be ready to measure varves with your mouse activated to **point & click** on varve boundaries.

5. Measuring Varve Thickness

Measuring varve thickness involves measuring the thicknesses of both summer and winter layers. Thicknesses are measured by pointing and clicking on boundaries on the image, which will generate horizontal lines to the right of the click point**.** All thicknesses are measured in only the vertical direction between horizontal lines. **Point & click** spots do not have to line up on a vertical line, but measuring on a vertical transect is usually the most accurate way to measure varves. Your 1st **point & click** on the image should be the bottom of the first summer layer that you want to measure on the image, which should be marked on the core liner. We use an ink mark separating by numbers on the core liner as can be seen in the practice images and on Figure 1. When you **point & click** you should see a red line appear that marks this boundary. The left end of this line is your 1st click point on the image. If it does not appear, **point & click** again because either your mouse click did not register or the program is expecting another response. The 2nd **point & click** should be at the top of the 1st summer layer/bottom of 1st winter layer, which produces a blue line. The left end of this line is your 2nd click spot on the image. Finishing the 1st varve is done with a **point & click** at the top of the 1st winter layer/bottom of next summer layer. Another red line will appear, which also serves as the beginning of the next varve. This procedure should continue up to the end of the last winter layer to be measured, which is marked on the core liner. All thicknesses are recorded as the vertical distances between lines you have posted on the images, which is why it is important to have bedding parallel to the upper and lower edges of the images as they are displayed in the program. Errors can be removed at any time by pressing the **shift** key. Multiple shift entries will remove multiple successive measurement lines back to the beginning of the image measurement.

6. Ending an Image: Accepting Measurements or Starting Over

If you are satisfied with your complete measurement of an image, hitting **Ctrl** after the last red line is entered will end the measurement of the image and you will be prompted to accept the measurements or start the image over. If you accept the measurements the program will ask for annotations or numerical comments.

If you decide to start over make sure that you fully re-open the image after the **point & click** lines from your previous attempt are removed. You will not have to recalibrate and can restart with Step 5 above. If your first **click & point** on the re-opened image gives you a blue line or error message, hit **shift** twice to remove it and a stray **click & point** (a red line, possibly off the image) that has caused the error.

7. Image Annotation and Comments

If you accept the image measurements you will be prompted to make any comments or annotations you may have on particular varves. Comments are useful for recording information about your measurements such as uncertainties or varve characteristics. For example, where you have measured one varve with your best informed decision, but are still somewhat uncertain as to whether it could be two varves you should insert a comment to indicate this uncertainty. All comments are in the form of numerical integer codes and you will either have to develop an integer code or use the Tufts code (see below). Another situation may arise where you have measured two varves with your best decision, but realize that it is possible that they may be one varve. You will want to make comments on both varve measurements to record your uncertainty. All measurement comments entered in the data file are also recorded as annotations on the analyzed images.

If you have no comments on an image that you have finished measuring, click **cancel** and the program will prepare for measurement of the next image. All varves with no comments will have a "0" automatically entered in the comments column in the data file except the 1st varve of each image, which will have the image number automatically entered. This will allow you to keep track of image positions in the data file.

To make a comment on a particular varve hit **OK** when prompted to make an annotation. This procedure can be repeated multiple times to make comments on as many varves as is required or to correct comments if you make an error. You will be prompted for a couplet number. Couplet numbers are displayed on the image as orange numbers. Comments may only be entered as a continuous string of integers with no spaces that will be tabulated in a separate column in the data file. The maximum number of digits that can be entered in the comment space is nine. We recommend that while you are measuring varves you only insert comments to deal with measurement uncertainties. Measuring varves is complex enough without trying to describe each varve at the same time. Separate documents are available and may be downloaded on the web page with a numerical code of comments used at Tufts to both characterize or describe varves and record measurement uncertainties (Measurement Code Card). You may download this system on the web site at: (see Ridge, 2012 reference in paper)
Note: ***The image number will automatically be posted in the data file at the first varve in each image under the "IM" column to mark the beginning of each image.***

When you are finished with the 1st comment you will be prompted to post a comment on another varve, which you can except (**OK**) or reject (**cancel**) as before. After making your last comment hit **cancel** in the image comment prompt box. You will then be prompted to continue to the next image, repeating the steps above (beginning with Procedure 3) by fully opening the next image and calibrating it. If you accept (hit **OK**), the comment prompt by mistake you can simply enter "0" as the comment for a varve with no comment to be entered. This will take you back to the comment prompt and you can hit (**cancel**) to leave the comment routine. Do not try to reverse or undo. When an image is complete, the program will automatically produce an annotated and fully-lined version of the image with the image name and number and your institution name (provided that you changed it in the script file, see section above Modifying Script Programs). The completed image will be placed (as an annotated Bitmap image) in the ANALVRV sub-folder in IMAGES.

To analyze a new image repeat procedures 3-7 above.

8. Ending a Core Set

When you are done with the last (ending) image, the program will ask you to **point & click** on the top of the core, which will post a yellow line at this position on the ending image. A total core thickness from the bottom of the 1st varve of the core to this line will be posted at the end of the data table that is compiled by the program. The top of the core is a very useful reference for finding positions in a core relative to outcrop samples or notes. Your final prompts will be to post comments for the varves of the last image (Procedure 7 above). When you are finished, the program will terminate and display the data table for the images you just measured. The data table has been saved for you in the RESULT sub-folder in IMAGES. You van edit the data table in an ASCII text editor such as Notepad or WordPad.

USING THE GRAY-SCALE ANALYSIS UTILITY (Varveprofile100.itm)

The gray-scale analysis routine can be used to create gray-scale profiles of varve sequences, which can sometimes be useful in measuring varves. The program will sample rows of a specified number of pixels along a transect. For each row the program will give an average gray-scale value (added RGB values) from 0-768. The values can then be plotted to graphically show the gray-scale values of a varve sequence. At this point we do not have an automatic varve measurement routine based on gray-scale profiles because of the many decisions that have to be made during measurement. The gray-scale analysis routine is most frequently used to quantify the intra-annual variability of layering leading to an analysis of seasonal deposition. The instructions below assume that you have downloaded all the necessary software and have set up your computer to run the software.

1. Starting Gray-scale Analysis

Start Image Tool 3.0 by double clicking the $IT_{3.0}$ icon on your desktop. (To install the IT3.0 icon on your desktop see the Software Installation instructions on the web site). After starting Image Tool, the gray-scale analysis routine can be found in the "Processing" pull-down menu under "Varve". If Varveprofile100.itm has been installed correctly there will be a choice of "Profile measurement".

Note: Hint boxes provide useful instructions and prompt you for actions as you proceed through the whole analysis routine. The boxes can be moved to convenient places on your screen during analysis. We don't recommend that you minimize Image Tool or use other programs on your computer while measuring a varve profile. Image Tool has been known to lose track of its progress, possibly due to stray mouse clicks outside the image that it does not know how to interpret.

If you downloaded the IMAGES folder to your computer there are two practice images in the RAWVRV sub-folder named: PROF2-1, PROF2-2. Use this practice set to see how the program operates with the following parameters:
The core set to open is: PROF2
They are Jpeg images. Choose 2
Starting image: 1
Ending image: 2

The example above uses 2 images, but we most frequently use the routine to analyze one image at a time. If you wanted to measure only one image you would choose that image as both the starting and ending image. You can also do part of an image sequence, for example starting with 2 and ending with 3.

2. Dimensioning a Profile Line

You will be prompted for the line width in pixels of the profile line(s) that you would like to sample perpendicular to bedding. Pixel characteristics for this width will be averaged. A choice of 10-20 is somewhat typical. You will also be asked for the number of profiles you would like to sample on each image. A prompt for profile separation will occur only when you have selected more than one profile per image. This is a number added in multiples to the values for successive profile lines so that the data from the different profiles may be plotted on the same graph without the lines lying on top of each other. If you choose 100, values for the first profile line will range from 0 to 768, the second profile line 100-868, third profile line 200-968, etc.

3. Loading Images

Loading of the images, because they are high resolution and are also being converted to gray-scale, may take a little time. You will see large white blocks appear for a few seconds during the conversion of RGB to gray-scale. Be patient!!!! The gray-scale image is then added to the sub-folder PROCESSED in IMAGES.

4. Opening Images and Calibration

You should open and maximize the first image as much as possible but there may still be slide bars if the image has large pixel dimensions. Use the slide bars to find the scale at the bottom or side of the image and proceed with the calibration procedure. A calibration line can be measured in any direction on the image. After accepting a calibration your mouse will be activated for locating the position of your first profile line.

5. Defining or Posting the Profile Line

Your next **point & click** after accepting the calibration will fix the position of your first profile line for gray-scale sampling. The profile line will always be vertical on your computer screen. If you accept it you will then post other profile lines in succession that you have requested. When you are finished with this image, the program will create data files of average gray-scale values for rows on your profile lines from the top (pixel row 1) to the bottom of the image. This may take a few seconds if your image is long and has wide profile lines. You will then be prompted to repeat the procedure above with other images you may have loaded. When you are finished there will be a numerical data file for each profile line in the RESULT sub-folder in IMAGES and an image with the positions of your profile lines will be placed in the ANALVRV sub-folder in IMAGES.

REFERENCES

Wilcox, C.D., Dove, S.B., McDavid, W.D., and Greer, D.B., 2002, UTHSCSA Image Tool Version 3.0: Freeware software available from the Department of Dental Diagnostic Science at the University of Texas Health Science Center at San Antonio: http://compdent.uthscsa.edu/dig/itdesc.html or search for “Image Tool 3.0”