

Testing the Accuracy of ImageJ

Testing the accuracy of ImageJ: Method

In order to test the accuracy of the automatic particle counting, manual bulk sediment counts were carried out on 10 images. Of course, the traditional method is not necessarily error free. Thus, a comparison must be made between the accuracy of the new, automated counting method and that of the traditional, manual counting method. To estimate the accuracy of the traditional method, repeat bulk sediment counts were carried out on 10 picking tray squares. Finally, in order to test the *overall* accuracy of this new method, tephra concentration analysis was undertaken on 10 core sections using the traditional method for comparison.

Testing the accuracy of ImageJ: Results

Analysing the new method presented in this paper was broken down into stages to allow thorough investigation of all potential sources of error. Essentially, if we are investigating the percentage tephra in different sections, there are two sources of error: miscounting of bulk sediment and miscounting/misidentification of tephra.

To quantify the error associated with bulk sediment counting in ImageJ, comparisons were made between manual and automatic counts. Within the context of this investigation, we consider manually counting particles in an image to have perfect accuracy; grains on the image are labelled when counted, and so no particles are missed or counted more than once. Ten images were selected at random and manual counts were carried out (Table S1). We find that the automatic counting method has an associated error of 4.85% (SE=0.88). This represents a 4.85% error in the bulk sediment count, *not* the percentage tephra. If, for example, a tephra concentration was calculated as 20%, a 4.85% error in bulk sediment count represents a range from 19.07% to 21.02%.

Table S1 - Accuracy of automated counting with ImageJ

Core	Section	Image No.	Manual Count	Macro Count	% Error
0-2	0-3mm	1	293	280	4.44
0-2	0-3mm	5	241	221	8.30
0-2	21-24mm	1	217	223	2.76
2-1	0-3mm	3	283	262	7.42
2-1	3-6mm	10	475	439	7.58
2-2	9-12mm	8	283	286	1.06
5-2	6-9mm	2	326	315	3.37
5-2	12-15mm	2	208	225	8.17

10-1	0-3mm	4	385	371	3.64
10-2	15-18mm	4	290	295	1.72
				Mean:	4.85%

To compare the accuracy of this new approach to bulk sediment counting with that of the traditional method, repeat counts were carried out on sections of Core 5-1 under an optical microscope. Ten picking tray squares were each counted twice (Table S2). The results suggest a 12.26% (SE=2.55) error associated with bulk sediment counting using the traditional method.

Table S2 - Accuracy of manual counting under optical microscope

Section	Square No.	1st Count	2nd Count	% Error
0-3	1	182	211	15.93
0-3	2	148	187	26.35
0-3	3	190	194	2.11
0-3	4	256	265	3.52
0-3	5	254	268	5.51
0-3	6	362	301	16.85
0-3	7	227	256	12.78
3-6	1	224	205	8.48
3-6	2	323	251	22.29
3-6	3	274	250	8.76
			Mean:	12.26%

Our results suggest that, in fact, automatic grain counting in ImageJ (4.85% error) is more accurate than manual grain counting (12.26% error). Of course, the error associated with the traditional bulk sediment counting method is entirely human error and this will vary between operators. Notwithstanding, these results suggest that for particle counting, ImageJ is more accurate than manual counting.

While it is not possible to directly calculate the rate of misidentification of tephra shards in either method, we can compare the final results of each method to give a rough indication of overall accuracy. Calculated tephra percentage for 10 sections, using both methods, is shown in Table S3.

The ImageJ method tends to underestimate the tephra percentage, compared with the manual method. The average error is 23.01% (SE=6.29). It should be noted, however, that larger

errors are more likely when tephra concentration is very low. In these cases, the presence of a single additional tephra grain can significantly affect the apparent concentration. As such, the effect of misidentification is much higher, and there is also a much larger variability between replicates. Furthermore, the stated errors in Table S3 assume that the manual approach to tephra quantification is perfectly accurate. Table S2 demonstrates that this is not the case, and so this may be an under- or an overestimate of the true error.

Table S3 - Overall comparison between traditional and ImageJ methods

Core	Section	% Tephra		% Error
		Traditional	Macro	
0-2	0-3mm	23.81%	19.18%	19.47%
0-2	3-6mm	0.91%	0.27%	70.40%
0-2	6-9mm	0.05%	0.05%	7.50%
2-1	0-3mm	8.12%	7.79%	4.08%
2-4	0-3mm	14.09%	12.47%	11.48%
2-4	3-6mm	1.33%	0.92%	31.08%
5-1	0-3mm	20.68%	14.08%	31.91%
5-1	3-6mm	4.84%	6.24%	28.95%
10-2	0-3mm	20.67%	16.15%	21.90%
10-2	3-6mm	4.33%	4.47%	3.34%
			Mean:	23.01%