Operator Error in Petrographic Point-Count Analysis: A Theoretical Approach

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Operator error in petrographic point-count analysis introduces bias into the estimates of proportion in a thin section. A correction for this bias, leading to an unbiased estimator of the true proportion in that thin section, is here proposed. Operator error also affects the confidence interval, and in this situation, too, an adjustment is possible. The approach proposed requires that the probabilities associated with operator error, categorized into A-type and B-type errors, are known or assumed. The A-type operator error tends to underestimate the true proportion in a thin section, whereas the B-type operator error tends to overestimate it. KEY WORDS: data processing, sampling, statistics, mineralogy, petrology, sedimentology.

INTRODUCTION

It is well known that petrographic point-count analysis (modal analysis) involves three types of error: specimen error, counting error, and operator error. Specimen error and counting error entail a sampling problem; by suitable experimental designs these errors can be reduced and their magnitudes estimated. Operator error is not related to sampling and is due solely to the analyst performing the counting. This type of error depends on such interrelated factors as the skill of the analyst, his experience, and the consistency of his tabulations. Even such seemingly unimportant factors as his degree of fatigue, his psychological state, and the physical conditions (light, magnification, etc) would affect the operator error. In general all these factors will play a role whether the counting is performed by one analyst (intraoperator source of variation) or by more than one analyst (interanalyst source of variation), the problem being more acute in the latter situation. The net effect of operator error is to introduce bias into the estimates of proportion in a thin section obtained by the binomial method (Chayes, 1956), the cell method (Demirmen, 1971), or any other suitable method designed for point counting.

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The problem of operator error in point-count analysis can be approached in three ways.

(1) An anticipatory or a priori approach whereby steps are taken, prior to the analysis, to ensure that the analyst(s) is skilled, experienced, and has adopted stringent tabulation conventions for consistency of tabulation. The working conditions (light, etc.) and the psychological state of the analyst(s) also should be optimized as far as possible. The anticipatory approach is aimed at the reduction of operator error; it is nonstatistical in nature, the decisions based on prior knowledge or judgment. The efficacy of the measures taken can be assessed by the approach mentioned in (2).

(2) An appraisal or a posteriori approach whereby, by a suitable analysis of variance design, the amounts of intra- and interoperation variation are estimated and their significance tested (e.g., Chayes and Fairbairn, 1951; Griffiths and Rosenfeld, 1954). If the amount of operator error is found excessive by significance tests, then the results can be discarded and the experiment repeated, presumably by taking cognizance of measures mentioned under (1).

(3) A remedial approach whereby proper adjustment for operator error is made in the estimates of proportion (and variance), assuming that the magnitude of operator error is known. This paper is a theoretical account dealing with the third approach.

STATEMENT OF PROBLEM

Regardless of its source or cause, operator error in point-count analysis can be categorized into two types: (1) A-type operator error, incurred in misidentifying a constituent C in a thin section and calling it non-C; and (2) B-type operator error, incurred in misidentifying a constituent non-C in a thin section and calling it C. Thus the A-type operator error tends to underestimate the true proportion in a thin section, whereas the B-type operator error tends to overestimate it. The net result would be to introduce bias into the estimates of proportion. The problem at hand, then, is to correct for this bias, i.e., to find an estimator of proportion that is unbiased. It will be shown that an adjustment for bias is possible provided that the probabilities of making A-type and B-type operator errors are known or assumed. The presence of operator error also affects the confidence interval, and in this situation, too, an adjustment is possible.

ADJUSTMENT OF PROPORTION

To formulate our approach, let \( p \) be the true proportion of some constituent \( C \) in a thin section, \( \hat{p} \) the estimator of \( p \) obtained by some method, say the cell