Statistical evaluation of correlations between sedimentary facies and spring water pH and temperature

INTRODUCTION

In order to ascertain whether distinct trends in pH and temperature exist within the context of sedimentary facies, the current study was undertaken in order to test whether probe measurements of water temperature and pH, which were taken at many sites along the spring outflow path that directly corresponded to the sedimentary regimes delineated in Fouke et al. (2000), could be mapped onto the five member facies model previously proposed. Agreement and disparity are discussed in terms of the statistical partitioning of an aqueous phase model.

METHODS

Over the course of several field campaigns, precipitated travertine in the outflow systems of Springs AT-1 and AT-3 were completed in order to identify the five sedimentary facies via the representative gross morphologies and crystal fabrics previously described (Fouke et al., 2000). Measurements of pH and temperature were subsequently taken with an Orion probe throughout each facies and within transition zones between facies. Probe rinsing and calibration were completed with dilute hydrochloric acid and standard buffers, respectively, as needed to ensure accurate results. For the purpose of statistical analyses, any and all measurements taken within a particular facies were considered as part of a single treatment. The few readings taken in transition zones were not included in these analyses, as there was no clear way of distinguishing the proper treatment in which to place the measurement. Statistical procedures were carried out using SAS software (SAS Institute Inc., SAS OnlineDoc®, Version 8, Cary, NC: SAS Institute Inc., 2000).

RESULTS

Figure 1 illustrates average pH measurements plotted as a function of average temperature for each of the five treatments considered in this study. The data generally take an exponential form, given the logarithmic nature of pH, and treatments are shown as having slight overlap in the cases of vent-apron channel, apron-channel-pond and proximal slope-distal slope; the pond and proximal slope treatments, however, overlie each other to a much a greater extent in pH-temperature space.

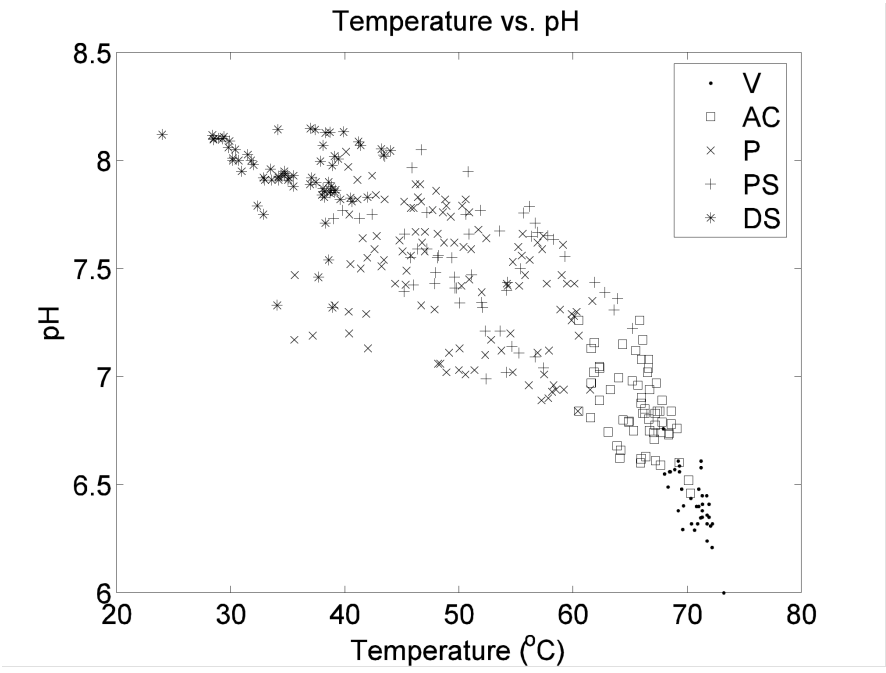

Figure 1: Average water temperature and pH with associated treatments corresponding to sedimentary facies at Springs AT-1 and AT-3 of the Mammoth Hot Springs Complex

Table 1: Statistical readout of the SAS npar1way procedure (Kruskal-Wallis Test)

Facies Comparison	$\chi^2_{calculated}$ Temperature	Probability $\chi^{2\ crit} > \chi^2_{calculated}$	$\chi^2_{calculated}$ pH	Probability $\chi^{2\ crit} > \chi^2_{calculated}$
1-2	65.3156	<0.0001	66.725	<0.0001
2-3	116.5639	<0.0001	93.3960	<0.0001
3-4	1.6289	0.2019	1.2976	0.2546
4-5	89.8420	<0.0001	65.0894	<0.0001

Pair-wise comparisons of average pH and average temperature by facies treatments, shown in Table 1, utilize the Kruskal-Wallis non-parametric test and the χ^2 statistic in order to test the null hypothesis that the distributions of these two aqueous parameters are identical between adjacent facies. No additional assumptions complicate these analyses, with the exception of the fact that data were assumed to have been taken from a completely randomized design within the confines of the spring outflow paths. The results of the comparisons, as evidenced by the calculated χ^2 values and associated low probabilities, indicate that there is a strong case for concluding that the null hypothesis can be rejected and that statistically separate distributions exist between treatments one and two, two and three, and four and five. The probability that treatments three and four comprise separate distributions is unlikely given that the probability of Type I error (falsely rejecting the null hypothesis) is greater than twenty percent.

DISCUSSION

The fact that pH and temperature can be separated into four distinct distributions lends supports the idea that a four member empirical model, which uses these parameters, could be constructed to identify distinctions in spring water from the solid phase underlying a carbonate hot spring. Application of such a model to other carbonate springs, therefore, may be possible, especially given the fact that carbonate hot springs from numerous sites appear to exhibit similar fluctuations of pH and temperature. The large data array compiled above for Springs AT-1 and AT-3 can be examined in terms of the means and standard deviations of each of the four statistically significant treatments in order to generalize the relationship between aqueous pH and temperature and the sediments over which the measurements were taken.