Calculated continuous-diffusion curves of lead-loss for various original ages are essentially straight lines for much of their length and begin to curve perceptibly only near the origin (17). For rocks of the same original age and moderate lead-loss, exceptionally good analytical data are necessary to differentiate between continuous diffusion and episodic loss. Although a straight line (episodic loss) fits our data well, the near-linear part of the continuous-diffusion curve for an original age of 800 million years could be fitted within the analytical error of the experimental points.

If the near-linear part of a continuous diffusion curve is extrapolated to the concordia curve, the intercept is progressively closer to the origin for younger original ages (18). Published zircon ages on billion-year basement rocks from western North Carolina have been interpreted with a continuous diffusion model (8). If, however, the episodic lead-loss model is used, these ages define two additional chords on the concordia diagram-one for layered granitic gneisses with an original age of 1300 million years and one for granitic gneisses with an original age of 1080 million years (Fig. 3). Both of these chords intersect the concordia curve at about 260 million years. Convergence of the three independently determined chords at the concordia curve gives added weight to episodic lead loss.

Lead loss is not related to the mid-Paleozoic metamorphism. The zircon ages of older Precambrian rocks which were raised to grades as high as that of the garnet amphibolite facies by this metamorphism appear not to have been disturbed by it (19).

Thrust faults in this part of the Blue Ridge do not involve rocks younger than Middle Ordovician, but in the western part of the Valley and Ridge belt, imbricate thrust faults override Pennsylvanian rocks (20). If the imbricate structure represents one generation of thrusting, that episode must be as young as Pennsylvanian.

A single episode of thrusting is a requirement of the currently popular thinskinned hypothesis for Appalachian structure. Cooper has attacked thinskinned tectonics by suggesting that major thrusting which involved basement rocks at the southeast edge of the Valley and Ridge belt began in the Middle Ordovician (21).

Zircon ages of basement and upper Precambrian rocks show no evidence of disturbance in the Middle Ordovician nor at the time of major regional metamorphism. They do suggest an episodic lead loss at about 240 million years, an age compatible with late Paleozoic thrust faulting in the western part of the Valley and Ridge belt. We suggest, therefore, that the emplacement of the Blue Ridge thrust sheet also occurred during the late Paleozoic Appalachian orogeny and that shearing associated with the thrusting disturbed the zircon ages (22). Multiple episodes of thrusting are difficult to reconcile with this hypothesis.

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Sedimentary Phosphate Method for Estimating **Paleosalinities: A Paleontological Assumption**

Abstract. Paleosalinity values in certain rocks determined by the sedimentary phosphate method differ from salinity estimates based upon contained fossil assemblages, geochemical methods, and existing stratigraphic controls. Some anomalous values are related to the abundance of fossil organisms known to be concentrators of calcium phosphate. Because of the abundance and diversity of organisms which might introduce significant errors into paleosalinity estimates, the sedimentary phosphate method seemingly is of limited applicability.

During the course of paleoecologic investigations of the Lower Kittanning (Pennsylvanian age) rocks of western Pennsylvania, two observations proved of unusual interest. First, when compared with fossil assemblages of similar age in the midwestern states, the western Pennsylvania assemblages are impoverished, that is, characterized by

the dominance (95 percent) of one or two species. Second, the maximum and mean sizes of the Lower Kittanning marine species are significantly smaller than their midwestern counterparts. Because reduced salinity could give rise to either of these effects, I examined published paleosalinity data for the Lower Kittanning rocks. Degens *et al.* (1) used techniques based on trace element distributions to divide the Lower Kittanning rocks into freshwater, brackish, and marine types. Weber *et al.* (2) were able to distinguish among freshwater, brackish, and marine environments which existed during early Kittanning time by using the ratios of the stable carbon isotopes. Although both of these techniques are useful, neither will definitively distinguish between rocks deposited in environments with a salinity of 20 parts per mille as opposed to 35 parts per mille.

With the publication of Nelson's (3) sedimentary phosphate method (SPM) for the determination of paleosalinity, it seemed that paleontologists had a potent paleoenvironmental tool at their disposal. Because Nelson's method should make possible an estimate of paleosalinity with an error of only ± 4 parts per mille, I used his method to obtain a paleosalinity profile for one Lower Kittanning section in the hope that the effect of salinity on the fossil assemblages could be evaluated.

Figure 1 shows the distribution of rock types, inferred paleosalinity, SPM paleosalinity, concentration of ironcombined phosphate (iron phosphate), and distribution of pyritic sulfur through a section at Kylers Corners, Pennsylvania. The inferred paleosalinity is based upon a synthesis of the known environmental requirements of the fossils and their living descendants, the trace element distribution, and the ratios of the stable carbon isotopes. The SPM paleosalinity was determined according to the method outlined by Nelson (4), and the percentage of pyritic sulfur (5) was determined with a sulfur analysis apparatus (Laboratory Equipment Corporation).

An examination of Fig. 1 reveals a poor correspondence between SPM paleosalinities and inferred paleosalinities. The SPM paleosalinities and inferred paleosalinities are similar for the upper part of the coal and the superjacent fissile shale. For this interval, SPM values are in accord with Habib's (6) interpretation for the origin of the coal based on an Everglades model. The paleoecology of the clam *Anthraconauta* and geochemical data from *Anthraconauta*-bearing shales (1, 2) suggest that the fissile shales originated in fresh to brackish water.

The first anomaly in the section occurs in the interpretation of the paleosalinity of the lower *Lingula*-bearing 7 NOVEMBER 1969 shale. The presence of the inarticulate brachiopod Lingula and geochemical data from Lingula-bearing shales (1, 2) suggest that these rocks originated in brackish water. In contrast, the SPM paleosalinity for these shales is about 30 parts per mille. This anomaly can easily be explained if one notes that Lingula shells are very abundant in this interval and that the shell of Lingula is composed of calcium phosphate. Thus a calcium phosphate concentrator may be giving rise to anomalous results by suppressing the effects of an increase in inorganically formed iron phosphate.

The inferred and SPM paleosalinities in the nodular and shelly shales are in general agreement. The SPM paleosalinities for the lower nodular shale lie between 26 and 30 parts per mille. As there is no reason to doubt these paleosalinity values, the lower nodular shale was probably deposited in slightly brackish water. Reduced salinity (7) could explain the paucity of shells in this shale, as well as the small size of the shells.

The shelly shale contains the most diversified fossil assemblage, yet two

species constitute 95 percent of all individuals in the shale. The SPM paleosalinity values for the shelly shale range from 32 to 33 parts per mille. Although these values are in the range characteristic of rocks deposited in marine environments, they lie below the present ocean mean salinity of 35 parts per mille. It is possible that low marine paleosalinity was responsible for the impoverished and stunted aspect of the fossil fauna in the shelly shale.

The SPM paleosalinity values for all samples of the upper nodular shale are 31 parts per mille. Reduced salinity could also account for the sparcity of fossils and their small size in this shale.

There is also good agreement between inferred and SPM paleosalinities in the upper *Lingula*-bearing shale. Although *Lingula*, a calcium phosphate concentrator, is present, anomalously high SPM paleosalinities were not found. Because *Lingula* is present in this interval, even though it is rare, the SPM values are probably too large by an unknown amount. As would be expected in a brackish environment, the iron phosphate concentrations are high



Fig. 1. Geochemical profile of the Kylers Corners section.

in the upper Lingula-bearing shale and remain so well into the overlying silty shale. The inferred and SPM paleosalinities in the silty shale and siltstone are in agreement, with the exception of an anomalous set of SPM values in the lower part of the siltstone. These anomalous values may be due to an influx of detrital calcium phosphate, as suggested by Müller (8); otherwise they are unexplainable.

Because of the anomalous SPM paleosalinities in the lower Lingulabearing shale, a limiting assumption must be met before Nelson's method can be used to estimate paleosalinities. This assumption is that all phosphate in the sample is of inorganic origin. Organic calcium phosphate concentrators in modern and ancient environments include the conodonts, phosphatic brachiopods, and vertebrate teeth, bones, dermal plates, and scales. The presence of any of these concentrators in any quantity in brackish and freshwater environments will give rise to erroneously high salinity values. Because many detrital rocks possess extremely variable amounts of calcium phosphate attributable to the above concentrators, this places a severe limitation on the applicability of Nelson's method for the determination of paleosalinity.

Müller (8) also pointed out two limitations associated with Nelson's method. The first was that calcium phosphate might be of detrital origin and, hence, a contaminant. Undoubtedly, the presence of detrital apatite or other phosphate minerals could give rise to erroneous estimates of salinities based on sediments deposited in freshwater and brackish environments; however, calcium phosphate of detrital origin is not found in all detrital rocks. Müller's second limitation was that, theoretically, iron phosphate under reducing conditions in the presence of H₂S would be transformed into ferrous sulfide. An examination of Fig. 1 reveals that pyritic sulfur and iron phosphate coexist. In fact, the pyritic sulfur content is highest in the freshwater and brackish portions of the section where the iron phosphate content is also highest. If Müller's theoretical argument is valid, it is difficult to understand how such small quantities of iron phosphate could survive in a reducing environment in which pyritic sulfur was forming.

Thus Nelson's method for the determination of paleosalinity is subject to two limiting assumptions. The first assumption is that all phosphate in the rock is of inorganic origin. Because of the widespread spatial and temporal occurrence of organisms capable of concentrating calcium phosphate, it is seldom possible to satisfy this assumption.

The second assumption, that of Müller, is that phosphatic minerals of detrital origin do not represent a significant portion of the phosphate present in the rock. This assumption will also be difficult to satisfy in detrital rocks. In order for SPM paleosalinities to have any meaning, the samples must be subjected to a complete assay for macro- and microfossils. Even then, comminuted phosphatic material may escape detection. These limiting assumptions are so restrictive that Nelson's method should not be used exclusively for the determination of paleosalinity; it should be used only

in conjunction with paleontological evidence and other geochemical techniques.

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Serum Cholesterol Reduction by

Chromium in Hypercholesterolemic Rats

Abstract. The addition of chromium (III) to the drinking water of rats in a normal laboratory environment on a hypercholesterolemic diet resulted in lower serum cholesterol concentrations whether the dietary carbohydrate was either sucrose or starch. However, rats fed the sucrose diet with chromium in drinking water had serum cholesterol concentrations similar to those of rats fed the starch diet without chromium in drinking water.

Chromium influences growth, longevity, glucose metabolism, lipid metabolism, and protein synthesis (1). Curran showed that chromium increased the incorporation of labeled cholesterol but acetate into (2),

Table 1. Effect of chromium on serum cholesterol. The results are expressed as the mean \pm standard error. There were 15 rats per group.

Diet	Serum cholesterol		
	Sucrose (mg/ 100 ml)	Starch (mg/ 100 ml)	Mean
Control	270 + 41 - 34	209 + 28 - 13	237
Chromium	208 + 13 - 13	$161 + 16 \\ -13$	182
Mean	236	183	

Schroeder's experiments, executed under conditions of rigid exclusion of chromium from the environment, suggested that a chromium deficiency resulted in elevated concentrations of serum cholesterol and aortic lipids, and that these conditions could be remedied by the addition of chromium to the diet.

After about 12 months of feeding chromium to rats, the concentrations of serum cholesterol were only slightly lowered (3), but after 17 months, the reduction in serum cholesterol became significant (4). Additional experiments only confirmed a trend toward lower concentrations (5). Schroeder's most recent experiments offered evidence that rats fed sucrose diets without chromium showed elevated concentrations

Table 2. Mean weight gain and food consumption. Results are expressed as the mean \pm S.E.

Diet	Sucrose		Starch	
	Weight gain (g)	Food intake (g)	Weight gain (g)	Food intake (g)
Control Chromium	$\begin{array}{c} 142\pm \ 8.5\\ 133\pm 11.4 \end{array}$	$505 \pm 20.5 \\ 519 \pm 29.0$	$\begin{array}{c} 149 \pm 7.2 \\ 155 \pm 9.5 \end{array}$	$643 \pm 32.4 \\ 579 \pm 24.2$

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