become inactive. This may explain the failure of certain sex-linked genes, for example *sf* in the mouse, to fit the hypothesis of the single-active-X.

Because of the evidence for gradients of inactivation and evidence that part or parts of the X are noninactivating, we have interpreted the V-type position effects as shown in Fig. 1*B*. While it is true that X-inactivity can occur only when there is more than one X present, this inactivity does not involve one entire X. Furthermore, those parts that can change to an inactive state spread inactivation not to the entire attached piece of autosome, but along a gradient to limited, though occasionally long, distances. Thus, on the simple interpretation of V-type position effect by the single-active-X hypothesis (Fig. 1*A*), all of the recessives in the intact autosome should be expressed. According to our interpretation (Fig. 1*B*), on the other hand, there are two reasons why a recessive might not be expressed: (i) it may be attached to a noninactivating part of the X (for example, *a*-locus in Fig. 1*B*); or (ii), although attached to an inactivating part of X, it may be too distant from it (for example, *c*-locus in Fig. 1*B*).

Figure 1*B* may be an oversimplification. Thus, there could be more than one inactivating and more than one noninactivating part of the X. Furthermore, there could be such differentiation within the inactivating part or parts that some regions are more potent than others.

It should also be pointed out that the results make it likely that inactivation can "flow" in both directions. Thus the *p* locus is inactivated by a "flow" to the right (Fig. 2) in the case of R2, R3, and R4, but by a "flow" to the left in the case of R5 and R6.

On the interpretation of Fig. 1*B*, rearrangements R3, R5, and R6 would involve breaks within the inactivating part of the X; and R2, a break within the noninactivating part. There are preliminary indications that R4 may also involve a break in a noninactivating part. Mapping of the X-chromosome breakpoints, which is now in progress, will be of great interest in connection with the interpretations developed in this paper.

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* Operated by Union Carbide Corporation for the U.S. Atomic Energy Commission.

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Analysis of Variance of the Composition of a Migmatite

Abstract. *To determine the variation of composition in a Front Range migmatite, an analysis of variance (nested design) was run on field measurements. The regional variation is too small to be considered significant, but the areal variation (between outcrops) is large enough to warrant comparison with some other measurable variable such as country rock composition.*

Migmatites, a mixture of granite and previously existing metamorphic rock, are a widespread phenomenon in plutonic terrains. This intimate association between the two rock types provides an opportunity for testing hypotheses of the origin and emplacement of granite (*1*).

The granite fraction of a migmatite may (model A) orginate *in situ* by anatexis (partial melting) of the country rock, or it may (model B) originate elsewhere and be emplaced in the country rock. (In this case the accessible portion of the migmatite is a chemically open system.) In model B two submodels may arise: (model B_1) the emplacement of the granite may leave the composition of the country rock essentially unchanged, or (model B_2) the granite material may permeate the country rock and make it more granitic.

These three hypotheses may admit of nonintuitive statistical tests: in model A the regression of some expression of the chemical composition of the country rock—say, silica percentage—upon the percentage of granite in the migmatite should have a negative slope and a high coefficient of determination (or correlation coefficient). In model B_1 a very low correlation should exist between the variables, and in model B_2 a positive slope and a high coefficient of determination should exist.

The first requirement for this study is a body of data previously nonexistent in geological literature: enough random measurements of the proportions of the end members to determine the composition and distribution of variation in a migmatite.

Our original target population (*2*) was the Idaho Springs gneiss in the Poudre River canyon, Larimer County, Colorado, along a 40-mile stretch from the Paleozoic overlap to the Home moraine (26 miles airline distance). It later became necessary to modify our target population, as we discuss below. In this area large, fresh exposures are abundant. The country rock portion of the migmatite consists of middle and upper almandine-amphibolite facies pelites and quartzofeldspathic rocks with minor amphibolites. A detailed study of the composition of and variation within the country rock is presently in progress. Data on this variation and heterogeneity may require extensive modification of the simple regression models proposed above.

An outcrop was defined as 100 feet of continuous, relatively fresh exposure (measured perpendicular to the foliation). The 112 outcrops (our sampled population) were grouped into five segments of 23 each (except the last, which had only 20). Seven outcrops were chosen by random number table from each segment. At each outcrop the distribution of granite (*G*) and country rock (*M*) was measured by steel tape along four 10-foot lines with random starts. Each 10-foot measurement is considered one sample. Two random specimens of country rock and one of granite were collected at each line for composition determination.

Large tabular bodies of granite were of different appearance from the small irregular masses of granite which make up the migmatite proper. Consequently, all such bodies greater than 12 inches thick were excluded as probably representing a separate population or cycle of emplacement. This treatment seems justified. Records were kept of the size and locations of these larger bodies; when these measurements are included in the calculations of composition, the distribution becomes apparently nonparametric.

Table 1. Analysis of variance.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Estimated mean square
Between segments	$k-1$	$np \sum_{i} (\bar{X}_{i..} - \bar{X}_{...})^2$	A	$\sigma^2+p\sigma_b^2+np\sigma_a^2$
	2	906.23	453.12	
Between outcrops within segments	$k(n-1)$	$p\sum_{i}\sum_{j} (\bar{X}_{ij.} - \bar{X}_{i..})^2$	B	$\sigma^2+p\sigma_b^2$
	18	4,785.80	265.87	
Between lines within outcrops	$kn(p-1)$	$\sum_{i}\sum_{j}\sum_{m} (\bar{X}_{ijm} - \bar{X}_{ij.})^2$	C	σ^2
	63	6,865.35	108.97	
Total	$knp-1$	$\sum_{i}\sum_{j}\sum_{m} (\bar{X}_{ijm} - \bar{X}_{...})^2$		
	83	12,557.38		

Grand mean: $\bar{X} = 76.54$. Between segments variance: $\sigma_a^2 = 6.33$ (a fixed effect). Between outcrops within segments variance: $\sigma_b^2 = 39.23$. Between lines within outcrops variance: $\sigma^2 = 108.97$. F $= A/B = 1.70$ (tabular values for 1 percent and 5 percent are 6.01 and 3.55). $F' = B/C = 2.44$ (tabular values for 1 percent and 5 percent are 2.55 and 1.77).

Beyond the third segment a granite gneiss, often not clearly distinct from the end members, was present. This made application of our original operational definitions of country rock and granite impossible (without resorting to intuitive notions of the origin of the gneiss), so the population was truncated at that point. Our results apply to the first three segments only.

The measurements of each line were reduced to percentage of country rock ($M \times 100/M + G$). The 84 lines range from 24.4 to 97.1 percent country rock, with a mean of 76.5 percent and a standard deviation of 10.1. The measurements are approximately normally distributed (*3*).

An analysis of variance was run on the outcrop measurements with a two-stage nested classification: lines within outcrops and outcrops within segments. This enabled us to estimate the between-segments variance, the between-outcrops-within-segments variance, and the between-lines-within-outcrops variance.

The segments were put into the experimental design in order to determine the magnitude of regional variation. The between-outcrops variance is a measure of the smaller-scale areal variation. The between-lines variance is an attempt to quantify that real, local variation which is apparent when observing an exposure.

The analysis of variance table (Table 1) gives our results; it is a common model and more or less self-explanatory. The segments are not a random sample from a population of possible segments and σ_a^2 is consequently the variance of a fixed effect. We consider the following as significant. The F-ratio A/B is very small, indicating that the difference between segments is no larger than might be expected from three samples of seven outcrops each, with the outcrops exhibiting the variation which they do. Consequently σ_a^2 may not be significantly different from zero and no large-scale regional variation is established for this case. On the other hand, the F-ratio B/C is large: the chance of such a value's occurring by accident is less than one in 100; this indicates that there is a real variation between outcrops.

It is this component of the variance (σ_b^2) in which we are most interested, and we are presently making compositional analysis of specimens in order to determine, by regression techniques, the reduction in σ_b^2 given the country rock composition. However, possible functional relationships to metamorphic grade (a measure of temperature or water vapor pressure or both), structural position (position in stress field), or distance from exposed granite plutons are also to be considered.

The very local (within outcrops) variance may also be associated with such variables as temperature, stress, or country rock composition, although it seems unlikely that these have or had steep local gradients. The local variance (σ^2) is more likely to be related to textural or other fabric characteristics of the country rock. Our present plans, however, call only for tests against the mineralogical and chemical properties of the country rock (*4*).

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References and Notes

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4. We acknowledge the advice and aid of W. C. Krumbein and F. A. Graybill and of B. F. Whitney, J. F. A. Jackson, and C. W. Ashcom. This work has been supported by funds from the Wayne State University, graduate division, and the Institute of Science and Technology.

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Pleistocene Sea Levels, Southeastern Virginia

Abstract. *Detailed study of post-Miocene stratigraphy in southeastern Virginia reveals at least 13 formations which show six Pliocene (?) and Pleistocene cycles of emergence and submergence, with maximum submergent sea levels near +45, +45, +20, +25, +15, and 0 feet, respectively. The newly established stratigraphic framework disproves earlier interpretations of "terrace-stratigraphy" and sea level chronologies.*

Interglacial sea levels higher than the present one are recorded by characteristic morphologic features and by marine sediments along coasts in many parts of the world (*1*). Where coasts have not been subsequently deformed, such features and sediments are useful for correlation merely on the basis of their altitudes above present sea level.

Although as many as seven interglacial sea levels have been inferred along the Atlantic Coastal Plain of North America, chiefly on the basis of morphologic features, only two have been confirmed by stratigraphic evidence: (i) a sea level near +25 feet,