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# Barium in Granitoid Rocks of the Basin and Range Province of Nevada, Utah, California and Arizona

By

Donald E. Lee, George A. Sellers,

Robert G. Johnson, and Harry J. Rose, Jr.

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## Abstract

The relation between CaO and barium is shown for 230 random samples of granitoid rocks collected from 115 plutons in the Basin and Range Province of Nevada, Utah, Arizona, and California. The lowest barium contents are found in the most felsic rocks, the highest in those rocks with a CaO content of 1.5-2.5 percent. Intermediate barium contents are found in the more mafic rocks, those with a CaO content of greater than 2.5 percent. It is concluded that the barium concentrations described can be explained on the basis of the fact that only biotites and potassium feldspars among the major rock-forming minerals have been found to concentrate barium relative to the matrix.

## Introduction

In a magmatic environment, most of the trace elements are taken up by the crystallizing silicates, substituting for the major elements largely on the basis of ionic size. The substitution of barium for potassium is a good example of this principle (Krauskopf, 1967, p. 587-589).

Lee and Van Loenen (1971) describe an equivalent of a large part (63-76 percent $SiO_2$) of the classic differentiation sequence that resulted mainly from assimilation of chemically distinct host rocks. In determining the distribution of barium in this pluton, Lee and Doering (1974) were surprised to find a well-defined trend toward lower barium values in the more felsic rocks. In other words, though barium substitutes for potassium in this pluton, one tends to decrease as the other increases. These writers concluded that the distribution of barium in this hybrid granitoid rock was controlled partly by the barium contents of the various sedimentary rock types assimilated. The present paper presents additional data that suggest that the distribution of barium described by Lee and Doering (1974) is not unusual for granitoid rocks in general.

## Analytical data

The hybrid granitoid rocks studied by Lee and Doering (1974) crop out in the Snake Creek-Williams Canyon area of the southern Snake Range, Nevada. The distribution of barium in those rocks is shown in figure 1, where barium is plotted against CaO (for a better point spread) and the equivalent ranges of $K_2O$ and $SiO_2$ are indicated. Barium rises from a minimum in the most felsic rocks to a maximum in those rocks containing 2.0-2.5 percent CaO (3.8-3.0 percent $K_2O$), and a secondary trend branches from the main trend where the rock contains 2.0-2.5 caO.

During the past several years one of us (Lee) has assembled a suite of granitoid rocks from the Basin and Range Province of Nevada, Utah, Arizona, and California. Two random samples were collected from each of two randomly selected plutons within each 1° x 1° area. The final suite includes 230 samples collected from 115 plutons. The distribution of the samples is shown in figure 2, where only odd-numbered samples have been plotted; at the scale of figure 2, the even-numbered samples would plot at the same locations as their odd-numbered counterparts. The 230 samples were analyzed for barium by means of X-ray fluorescence and for calcium by means of flame atomic absorption. The relation between CaO and barium contents in the 230 samples of granitoid rocks from the Basin and Range Province is shown in figure 3. The scatter of points is much greater in figure 3 than in figure 1, which is not surprising in

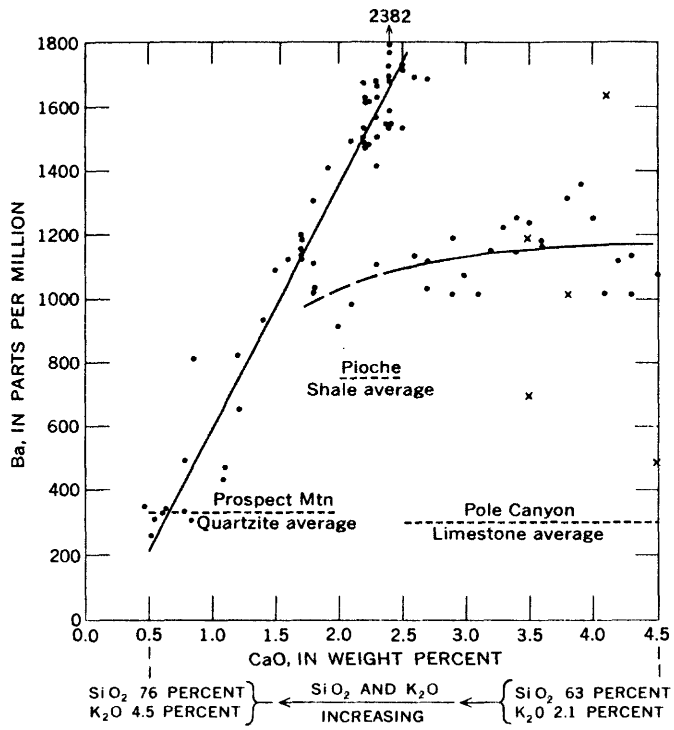


Figure 1.--Relation between CaO and Ba contents in granitoid rocks of the Snake Creek-Williams Canyon area, southern Snake Range, Nevada. Equivalent ranges of contents of $SiO_2$ and $K_2O$, in weight percent, are indicated. Average Ba contents of sedimentary rocks indicated on parts of diagram representing assimilation of those rocks. (From Lee and Doering, 1974, fig. 1.)

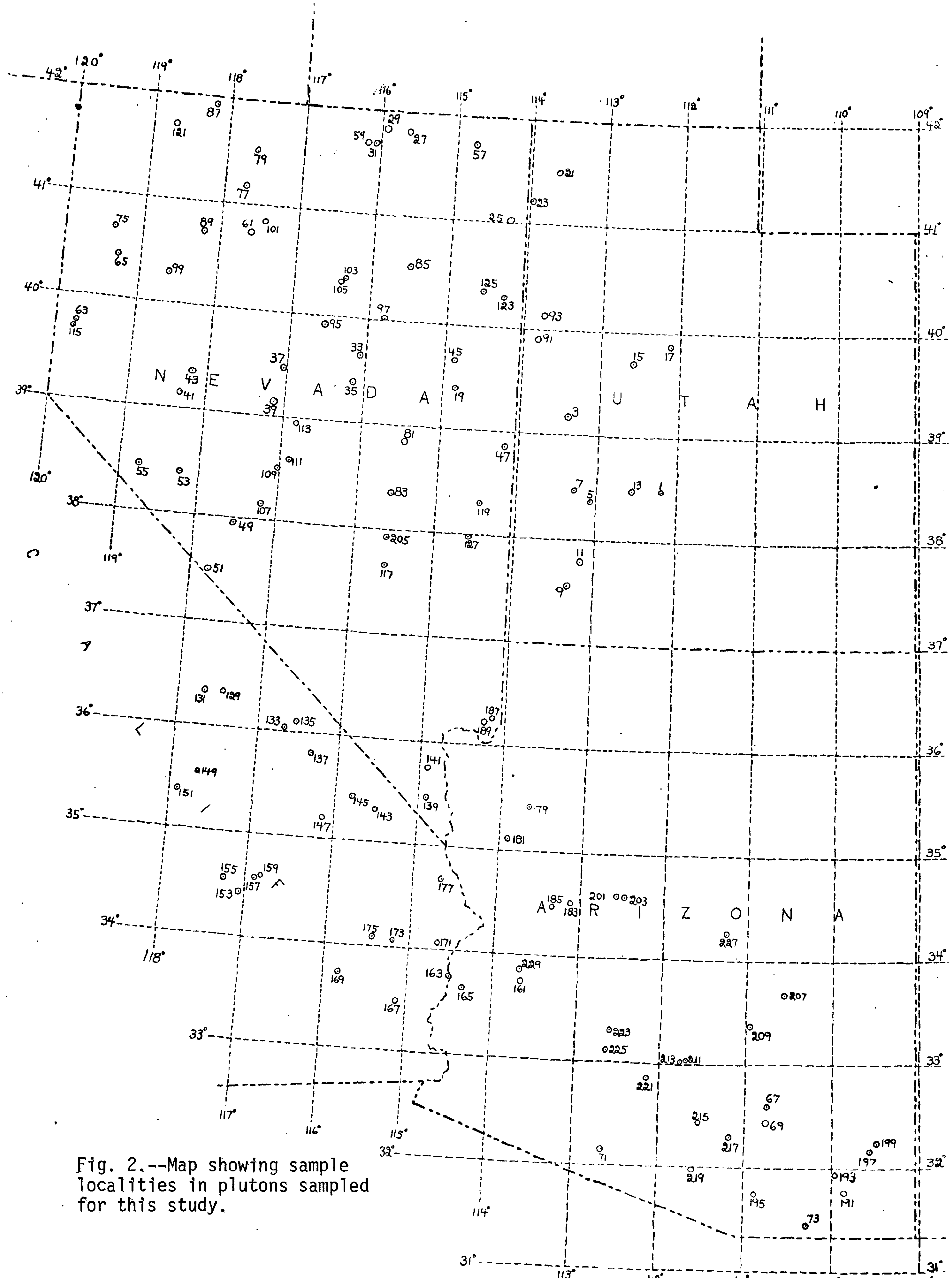


Fig. 2.--Map showing sample localities in plutons sampled for this study.

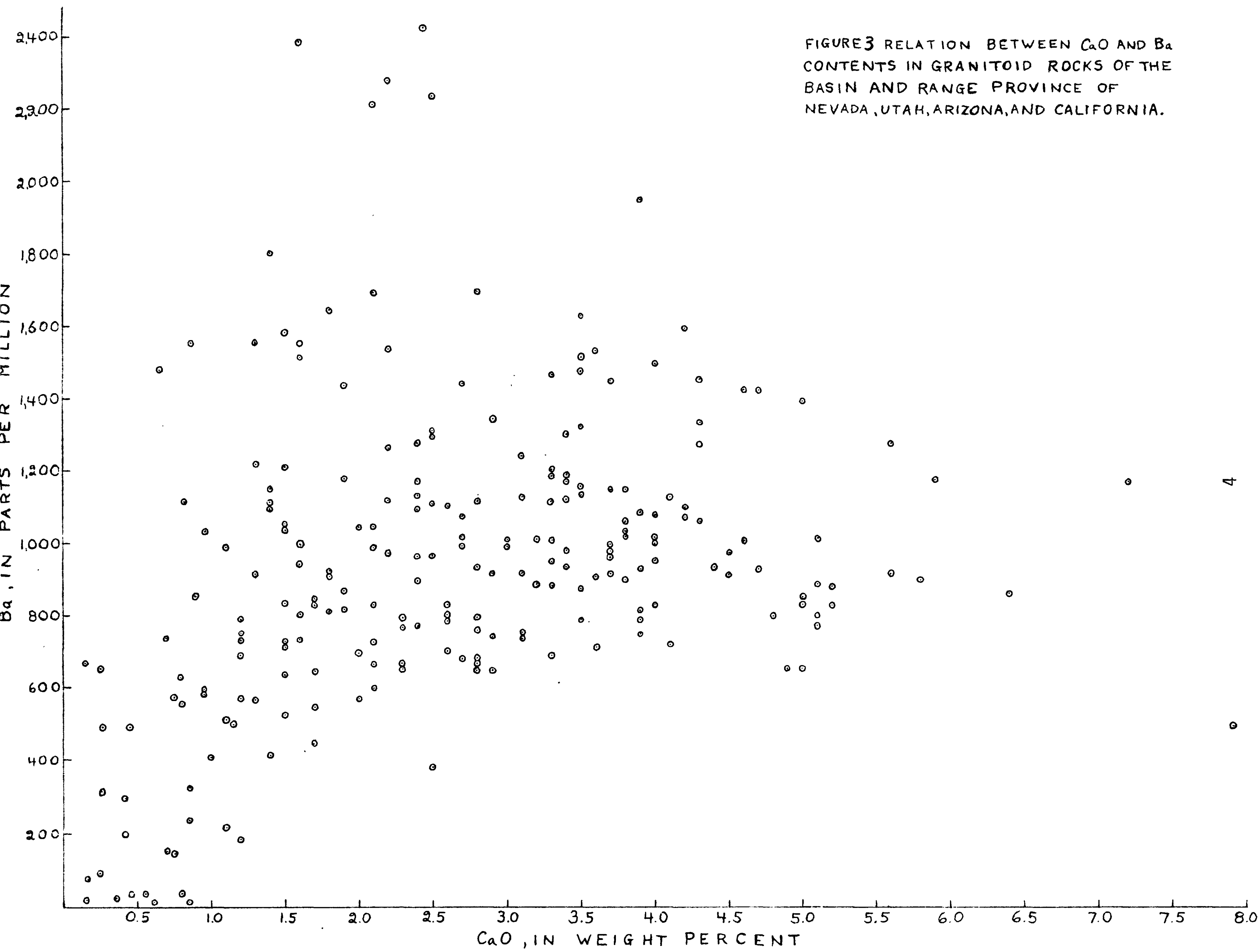


FIGURE 3 RELATION BETWEEN CaO AND Ba CONTENTS IN GRANITOID ROCKS OF THE BASIN AND RANGE PROVINCE OF NEVADA, UTAH, ARIZONA, AND CALIFORNIA.

view of the fact that figure 1 represents data for a single intrusive mass, while figure 3 is a composite of data for 115 separate plutons distributed over a very wide area. Despite the greater scatter of points in figure 3, their general distribution is rather similar to those in figure 1. This would seem to indicate that the distribution of barium within that equivalent of part of the clastic differentiation sequence represented by the pluton exposed in the Snake Creek-Williams Canyon area of the southern Snake Range, Nevada is not unusual.

Results of the present study cast doubt on the idea that the barium contents of the assimilated rocks had any significant bearing on the distribution of barium in the pluton resulting from assimilation in the southern Snake Range (fig. 1). In fact data for one of the plutons sampled during the present study fail to support the idea that the barium content of an intrusive rock is likely to be influenced by the barium content of the country rock. Shawe and others (1967, 1969) describe bedded barite deposits in East Northumberland Canyon, Toquima Range, Nye County, Nevada. Rye and others (1978, p. 223) stated that some of the bedded barite deposits..."have been slightly recrystallized in places due to the thermal effect of a nearby Jurassic pluton". This same Jurassic pluton was included in the present study (fig. 2, samples 113 and 114), and the Paleozoic sedimentary rocks invaded by this pluton contain zones of bedded barite (D. R. Shawe, oral commun., 1980). Samples 113 and 114 contain 4.0 and 3.8 weight percent CaO and 1,078 and 1,021 parts per million barium, respectively. As is apparent from figure 3, samples 113 and 114 are not notably rich in barium; this is especially true when the barium-rich nature of the sediments that are cut by the pluton from which the samples came is considered.

## Discussion

The distribution coefficient of a minor element is the degree of its incorporation into a specific mineral. For barium it is defined as follows: D = concentration of barium in the phenocryst/concentration of barium in the melt. A consideration of the barium distribution coefficients of different minerals will give us some idea of how barium will behave during crystallization of those minerals. This may help us to understand the distribution of points in figures 1 and 3.

The barium distribution coefficients to be considered have been calculated empirically from published data. For example, the barium content of phenocrysts may be compared with that of a ground mass in a volcanic rock, assuming equilibrium conditions. The exact barium content of a given mineral in a particular rock depends on many factors, such as pressure, temperature, availability of barium, presence of competing elements, structure of the mineral and its position in the sequence of separation from the melt, and other parameters (Puchelt, 1972, p. 56-D-15). However it is apparent that these are second order factors, for all of the reported distribution coefficients for barium are of the same order of magnitude (C. E. Hedge, written commun., 1980).

Only biotites and potassium feldspars have been found to have barium distribution coefficients greater than one; clinopyroxenes, orthopyroxenes, hornblendes, garnets, plagioclases, and olivines all were found to have values of less than one (Higuchi and Nagasawa, 1969; Philpotts and Schnetzler, 1970; Schnetzler and Philpotts, 1970; and Nagasawa and Schnetzler, 1971). Thus in granitoid rocks, such as those shown in figures 1 and 3, only biotites and potassium feldspars among the major rock-forming minerals have been found to concentrate barium relative to the matrix.

Therefore one might expect a low barium content in the more basic rocks, those that form before either biotite or potassium feldspar begins to crystallize. As biotite begins to crystallize the rocks should contain larger amounts of barium; still larger amounts might be expected in those rocks containing both biotite and potassium feldspar. The residual melt would then be depleted in barium, leaving little available as the most felsic rocks begin to crystallize. Such a combination of factors might explain the very low barium contents found in some of the most felsic rocks (figs. 1 and 3).

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