A FIELD METHOD FOR MAKING A QUANTITATIVE ESTIMATE OF ALTERED TUFF IN SANDSTONE

By R. A. Cadigan

Trace Elements Investigations Report 174

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

OFFICIAL USE ONLY

Geology and Mineralogy

This document consists of 11 pages.
Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A FIELD METHOD FOR MAKING A QUANTITATIVE ESTIMATE OF ALTERED TUFF IN SANDSTONE*

By

R. A. Cadigan

September 1954

Trace Elements Investigations Report 174

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

USGS - TEI-174

GEOLOGY AND MINERALOGY

Distribution (Series A)	No. of copies
Argonne National Laboratory	1
Atomic Energy Commission, Washington	1
Division of Raw Materials, Albuquerque	1
Division of Raw Materials, Butte	1
Division of Raw Materials, Denver	1
Division of Raw Materials, Douglas	1
Division of Raw Materials, Hot Springs	1
Division of Raw Materials, Ishpeming	1
Division of Raw Materials, Phoenix	1
Division of Raw Materials, Richfield	1
Division of Raw Materials, Salt Lake City	1
Division of Raw Materials, Washington	3
Exploration Division, Grand Junction Operations Office	6
Grand Junction Operations Office	1
Technical Information Service, Oak Ridge	6
Tennessee Valley Authority, Wilson Dam	1
U. S. Geological Survey:	
Alaskan Geology Branch, Menlo Park	1
Fuels Branch, Washington	1
Geochemistry and Petrology Branch, Washington	1
Geophysics Branch, Washington	1
Mineral Deposits Branch, Washington	2
E. H. Bailey, Menlo Park	1
A. L. Brokaw, Grand Junction	2
K. L. Buck, Denver	1
J. R. Cooper, Denver	1
N. M. Denson, Denver	1
C. E. Dutton, Madison	1
W. L. Emerick, Plant City	1
L. S. Gardner, Albuquerque	1
M. R. Klepper, Washington	1
A. H. Koschmann, Denver	1
R. A. Laurence, Knoxville	1
D. M. Lemmon, Washington	1
J. D. Love, Laramie	1
V. E. McKelvey, Menlo Park	1
Q. D. Singewald, Beltsville	1
J. F. Smith, Jr., Denver	1
A. O. Taylor, Salt Lake City	1
A. E. Weissenborn, Spokane	1
TEPCO, Denver	2
TEPCO, RPS, Washington, (Including master)	3
	58

CONTENTS

ILLUSTRATION

A FIELD METHOD FOR MAKING A QUANTITATIVE ESTIMATE OF ALTERED TUFF IN SANDSTONE

By R. A. Cadigan

ABSTRACT

The use of benzidine to identify altered tuff in sandstone is practical for field or field laboratory studies associated with stratigraphic correlations, mineral deposit investigations, or paleogeographic interpretations. The method is based on the ability of a saturated benzidine ($C_{12}H_{12}N_2$) solution to produce a blue stain on montmorillonite-bearing tuff grains. The method is substantiated by the results of microscopic, X-ray spectrometer, and spectrographic tests which lead to the conclusions that: (1) the benzidine stain test differentiates grains of different composition, (2) the white or gray grains which are stained a uniform blue color are fragments of altered tuff, and (3) white or gray grains which stain in a few small spots are probably silicified tuff. The amount of sand grains taken from a hand specimen or an outcrop which will be held by a penny is spread out on a nonabsorbent white surface and soaked with benzidine for 5 minutes. The approximate number of blue grains and the average grain size are used in a chart to determine a reference number which measures relative order of abundance. The chart, based on a volume relationship, corrects for the variation in the number of grains in the sample as the grain size varies.

Practical use of the method depends on a knowledge of several precautionary measures as well as an understanding of the limitations of benzidine staining tests.

INTRODUCTION

The use of benzidine stain to identify altered tuff in sandstone is practical for field or field laboratory studies. The method described in this paper provides a quantitative estimate of tuff that may be used to provide comparative data for well log correlations, the study of mineral deposits as related to the presence of volcanic tuff, and paleogeographic interpretations based on regional distribution of tuff, as well as facilitating the petrologic determination of rock composition. This paper has been prepared on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

BASIS FOR USE OF BENZIDINE

The field method for identifying and estimating the quantity of altered tuff in sandstone is based on the staining of montmorillonite-bearing tuff grains with a saturated benzidine solution. Tests by Mielenz, King, and Schieltz (1950) support the use of benzidine as a stain for determining montmorillonite. Montmorillonite is a clay mineral believed to be derived from silica poor, silicic-alkalic or alkalic-calcic intrusive and extrusive rocks, and volcanic glass. In sediments montmorillonite occurs in a pure state, intermixed in all proportions with hydromica or kaolin, and as an inclusion in altered volcanic tuff. The most conspicuous occurrence of montmorillonite is in the swelling clay mixture called bentonite.

The solution required for the tests may be prepared by adding a small pinch of flake benzidine ($C_{12}H_{12}N_2$) to an ounce of distilled water in a tinted bottle equipped with a medicine-dropper cap. The solution should be allowed to stand at least 2 hours and preferably overnight before it is used. As long as solid benzidine remains in the bottom of the bottle, the solution will be saturated. It may be replenished by adding distilled water. A fresh solution should be prepared monthly. The solution will be most reliable if direct exposure to sunlight is kept to a minimum.

For some undetermined reason, not all montmorillonite reacts to the benzidine stain, therefore, the failure of a bentonitic-appearing clay to turn blue when treated with benzidine solution does not always indicate absence of montmorillonite.

PRIOR USE OF BENZIDINE

Several geologic formations of the Colorado Plateau region are partly made up of sandstones containing different amounts of altered tuff. Of these formations, the Morrison formation of Late Jurassic age and the Shinarump conglomerate and Chinle formation of Late Triassic age contain the most conspicuous amounts of volcanic debris. The use of benzidine as a field test for altered tuff and montmorillonite clay was introduced on the Colorado Plateau by Waters and Granger (1953) during their qualitative study of volcanic debris in the Morrison and Chinle formations. Others, including the author, have continued using benzidine with the idea of determining its limitations and best uses for field studies.

TESTING OF THE METHOD

To test the effectiveness of the stain, the author selected a tuffaceous sandstone which was established as such by thin-section study using Pirsson's (1915) criteria, crushed small portions of it in a watch glass and saturated it with benzidine solution. The following reactions were observed under a binocular microscope:

1. A pasty clay, which occurred as interstitial wads or formed thin films over quartz and feldspar grains, was stained an intense blue color.

2. Some white porous or sponge-like grains turned a uniform moderate shade of blue throughout.

3. Some white amorphous grains became spotted with widely scattered intensely blue spots which gave the impression of blue cryptocrystalline amygdaloids in an amorphous white groundmass.

4. Grains which gave no reaction to the stain were either clear quartz, feldspar, or white or colored amorphous grains.

Individual grains were hand picked from the watch glass. Two types were selected, the uniformly blue grains and the white grains with the blue spots. The grains were submitted to Mrs. A. D. Weeks of the U. S. Geological Survey laboratory in Washington, D. C., for analysis.

Analysis of the uniformly blue grains yielded the following result:

Spectrographic			X-ray spectrometer
Major	Minor	Trace	
Si, Al	Mg, Ca, K, Na, Fe	Ti, Mn, Ba, Zr,	Quartz and orthoclase

Analysis of the blue-spotted grains yielded the following result:

Spectrographic			X-ray spectrometer
Major	Minor	Trace	
Si	Al, Na, Fe	Ca, K, Ti, Ba	Quartz

Interpretations of the results are summarized in three general conclusions:

1. The benzidine stain test differentiated grains of different composition.

2. The thin-section study of the sample indicated that the rock was composed of grains of clear quartz, altered tuff, clear feldspar, and "chert". The "chert" could be either sedimentary chert or silicified tuff or both. By process of elimination it is reasoned that the blue-stained grains were grains of fragments of altered tuff.

3. Similarly it is reasoned that the blue-spotted grains were fragments of silicified tuff which still contained small isolated amygdules of montmorillonite. These grains were probably subjected to alteration and leaching with a subsequent loss of minor elements; following the leaching or in conjunction with it, silica was deposited in all available spaces.

PROCEDURE FOR A FIELD STUDY

Based on the laboratory experience with the benzidine stain, the following procedure has been applied in the field to obtain a quantitative estimate of the altered tuff contained in sandstone.

1. Brush or pinch from the sandstone about a teaspoon of sand and catch on a sheet of creased notebook paper.

2. Crush any aggregates present and discard any which are excessively large and hard.

3. Pour the sand from the paper on to penny until the penny is completely covered by a cone-shaped pile.

4. Transfer the sand from the penny to a porcelain streak plate or some flat white nonabsorbent surface.

5. Thoroughly wet the sand with drops of benzidine solution and flatten any small piles of grains with a straightened paper clip or similar tool.

6. Estimate as carefully as possible the most common grain size by means of a hand lens or binocular microscope, and a size stick, or millimeter scale.

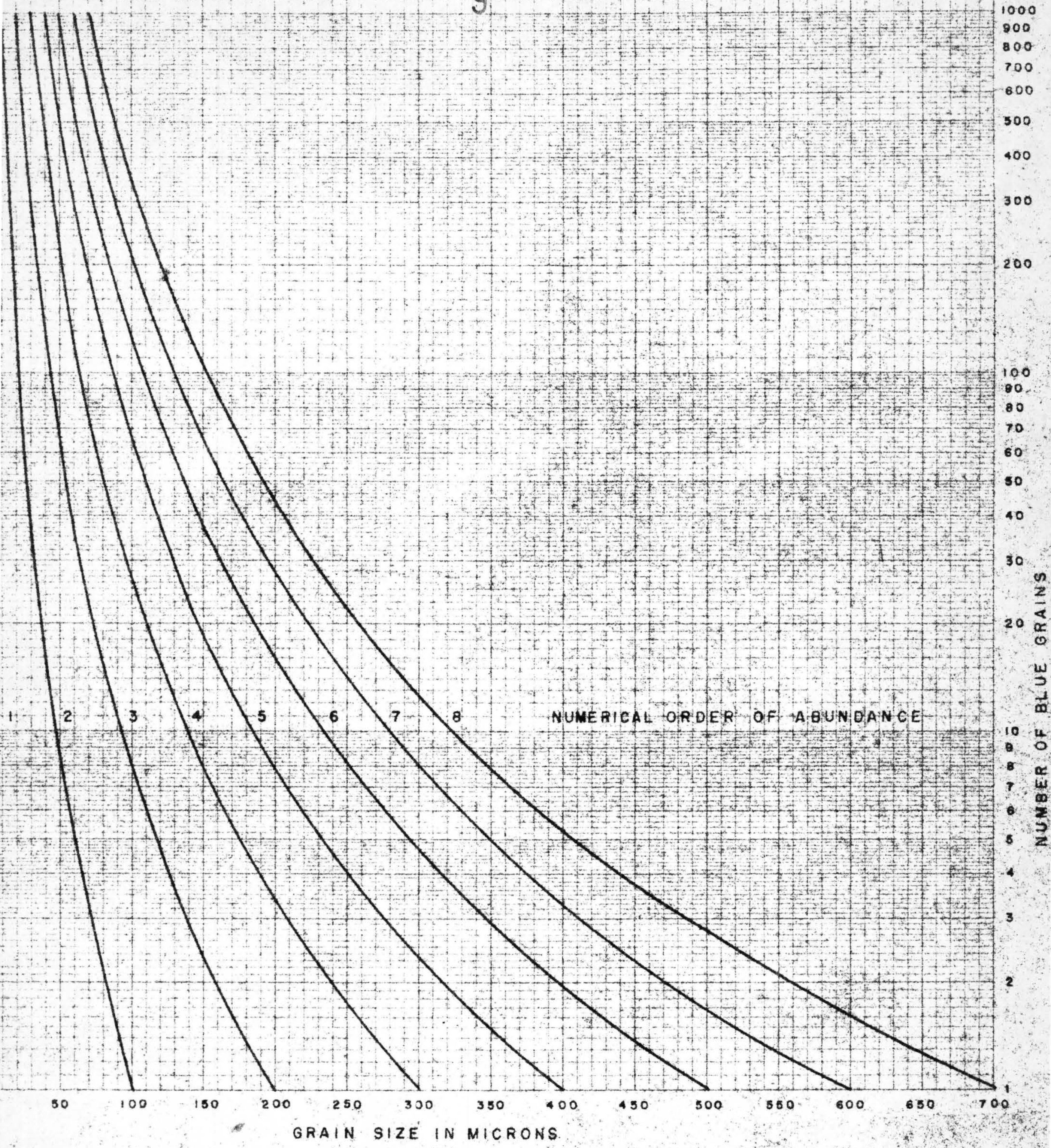
7. After the sand grains have been wet by the benzidine solution for 2 to 5 minutes, count the number of uniformly blue grains present. The count need not be precise, but the fewer the blue grains present, the more accurate the count should be. In a sand with average grain size of 0.200 mm, the difference between 10 to 20 blue grains is much more significant than that between 100 and 200 (fig. 1).

8. Enter the average grain size and the number of blue grains into the chart (fig. 1) and determine the degree of abundance in terms of the numbers 1-8. The purpose of the chart is to correct for the proportion of tuff to nontuff grains on the assumption that the number of grains in the sample used will vary inversely with the average grain volume. The numbers 1-8 were chosen arbitrarily to measure order of magnitude.

PRECAUTIONS AND LIMITATIONS

1. When benzidine solution is added to crushed sandstone it reacts with any available ions of ferric iron (Fe^{+++}) or similar oxidizing agent. Such ions may be present in thin iron oxide coatings or grains. If the benzidine reacts with the iron oxide it will produce a faint blue color, but will also tend to bleach the pale reddish grains. The bleached grains will contrast with the unbleached sand and the geologist can recognize what has happened and discount the pale blue stain observed.

2. In a sandstone which contains reacting montmorillonite, some quartz and feldspar grains may have a thin coating, or thin patches of the clay adhering to the grain surfaces. The clay film will stain an intense blue and give the impression that the whole grain is blue. Ordinary care in observation will prevent confusion in this case; the clay film will usually be discontinuous and the clear quartz or feldspar grain will show through.



EXPLANATION

x Grain size in microns

y Number of blue grains

$y = \frac{c^3}{x^3}$ Formula for each curve where c=x when y=1

Figure 1. CHART FOR DETERMINING ORDER OF ABUNDANCE OF ALTERED TUFF GRAINS

3. As grains of tuff undergo alteration and silicification, they may be partly altered to montmorillonite, kaolin, or hydromica. The soluble minerals formed may be leached because of the general porous or vesicular structure of the tuff. At any time during the alteration process, silica in the form of cryptocrystalline quartz may be deposited as a replacement of other minerals, or as a cavity filler. Thus, tuff grains in all stages of alteration and silicification may be found together. Altered tuff grains which have lost all of their montmorillonite by leaching or grains which have been completely silicified will not react to the benzidine stain test. In the procedure outlined, only the tuff grains that stain a uniform blue color of high or moderate intensity are counted. This separation on the basis of color reaction may be considered rather arbitrary and might be unsatisfactory in the case of some sandstones. However, sandstones of the Salt Wash member of the Morrison formation contain a conspicuous amount of white angular cryptocrystalline sand-size grains which probably are tuff grains in different degrees of alteration and silicification or sedimentary chert which cannot be easily differentiated from the tuff. The intergrading of the two rock types in this instance justifies the restricting of the grain count to the white grains which are stained uniformly blue by benzidine. White grains which show small streaks or scattered spots of blue stain could probably be regarded as silicified tuff.

4. As the grains that have been wet by benzidine solution dry, the blue stain may often change to a pale green or yellowish green. The significance of this color change has not been determined. When the grains are dampened, the color changes to blue again.

5. The method of spot checking for tuff by squirting benzidine on hand specimens is not reliable. The reason for this is that some grains of tuff requires 5 minutes to react to the stain. When benzidine is squirted on a hand specimen of porous sandstone, the stain is absorbed rapidly into the interior of the fragment, the outer visible grains dry in less than a minute, and the grains of tuff which would turn blue only after 2 or 3 minutes of exposure do not stain. However, there need be no hesitation about testing claystones and mudstones by wetting hand specimens with benzidine for the purpose of determining whether or not the reacting type of montmorillonite is present, because the benzidine solution is usually confined to the outer surface of the rock.

6. It must be emphasized that the benzidine staining method as a test for montmorillonite, like all similar staining methods, is an imperfect tool and must be applied with caution when used alone and without other means of verification. For further discussion of the limitations of the benzidine test refer to articles by Page (1941), Mielenz, King, and Schieltz (1950), and Keller (1954).

LITERATURE CITED

Mielenz, R. C., King, M. E., and Schieltz, N. C., 1950, Staining tests, A. P. I. project 49, Preliminary Rept. no. 7, section 6; Columbia University.

Page, J. B., 1941, Unreliability of the benzidine color reaction as a test for montmorillonite: Soil Science, v. 51, p. 133-140.

Pirsson, L. V., 1915, The microscopic characters of volcanic tuffs-A study for students: Am. Jour. Sci., v. 40, p. 191-211.

Waters, A. C., and Granger, H. C., 1953, Volcanic debris in uraniferous sandstones and its possible bearing on the origin and precipitation of uranium: U. S. Geol. Survey Circ. 224.

UNPUBLISHED REPORT

Keller, W. D., 1954, Preliminary study of the clay minerals in some red and green mudstones from the Colorado Plateau: U. S. Geol. Survey Trace Elements Memo. Rept. 786.