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Progress Report (1953) on the Revision of Washington's Chemical Analyses of Igneous Rocks (U.S.G.S. Prof. Paper 99), presented at the First International Symposium on Geochemistry, under the auspices of the International Union of Chemistry, in Zurich, August 11-13, 1953.

by

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#### INTRODUCTION

In October of last year, when I was here in Zurich, it was my privilege to talk with Professor Niggli about the revision of Washington's "Chemical analyses of igneous rocks" which the United States Geological Survey is undertaking. It was then that he suggested the possibility of a progress report at this meeting in order that information about the revision would be available to those who are most interested. At the time that I talked with Professor Niggli the place of this meeting had not been decided, but I think he hoped that it would be in Zurich. Today, we must proceed without him, but I am sure that you must feel, as I do, that he is here in spirit and that he expects us to continue the work as he would have, - with enthusiasm, with strength, and with happiness.

#### BACKGROUND

Henry S. Washington's first compilation of chemical analyses of igneous rocks was published in 1903, by the United States Geological Survey, as Professional Paper 14. It included 2881 analyses that had appeared in the literature between 1884 and 1900. Washington continued his search of the literature and by 1913 had collected twice the number

that were published in the previous 17 years. Although by this time Washington had joined the staff of the Geophysical Laboratory, the Geological Survey published his work. Professional Paper 99 appeared in 1917. It is a large, quarto-size volume of 1200 pages, contains 8602 analyses, and gives locality, reference, name, and analyst for each analysis. The analyses are classified according to the system which Washington, Cross, Iddings, and Picsson devised and the CIPW norm is given for 4980 rocks.

Almost 40 years have elapsed since the publication of Professional Paper 99. Although the need for a comparable compilation has been widely acknowledged, none has appeared. Between 1937 and 1941, Professor E. B. Mathews at Johns Hopkins University, with financial assistance from the Geological Society of America, did considerable work on a compilation but was unable to complete it. This material is available to us and we plan to use it to check our work. Unfortunately, some parts of it have been lost.

A few years ago, Dr. Earl Ingerson circulated a questionnaire to petrologists to obtain opinions concerning a revision. The replies from 187 people were overwhelmingly in favor of the revision; only one person questioned the value and that was in relation to the high cost of such a project. Opinion also favored extending it to include both sedimentary and metamorphic rocks. Americans were opposed to including the analyses from Professional Paper 99, but Europeans, realizing the extent of book damage by the World War, emphasized the need for including analyses from the former publication. Actual work on the project had to await the appropriation of funds, but in

January 1952 Mr. Theodore Woodward and I were assigned to full time on the project under the supervision of Dr. Earl Ingerson and Dr. George T. Faust.

In my report to you today I shall first outline the general plans for the project. Then I shall describe in more detail the methods of procedure we are using, particularly in the compilation work. Finally, I shall tell you what we have accomplished up to the present time.

#### GENERAL PLANS

The project is a long-range one and the scope is large. Even so, it divides rather naturally into four main phases. These are:

1. Compilation of the analyses
2. Calculation of the norms
3. Interpretation of the data
4. Publication

The compilation requires a thorough, extensive, and systematic search of the world literature since 1914, the year at which Washington terminated his search. The end of 1953 has been set as the cut-off date, thus concluding an even 40 years. Not only are the analyses themselves of both igneous and metamorphic rocks to be compiled, but also pertinent, related information such as occurrence, age, mode, and analytical data that will be used in the interpretation. After the compilation of the analyses published since 1914, the earlier ones in Professional Paper 99 will be combined with them in the files

so as to be available in the same form for interpretation.

At the present time it is planned to calculate the CIPW norms, using the modifications suggested by Barth simultaneously with the compilation and to recalculate the norms of the analyses in Professional Paper 99. If it is possible, Niggli numbers will also be computed.

When the material has been compiled and calculated, it is planned to transfer the results to machine punch cards according to a code system. In this way we hope to make the large mass of data flexible for interpretation. The punch cards can be sorted, shuffled, merged, or counted by machines to give statistical data for various categories. Dr. Ingerson and Dr. Faust will make the interpretations.

Publication of the material as a professional paper by the Geological Survey is expected. It is planned to combine the analyses in Professional Paper 99 with the new material and publish it as a single compilation for the period 1884 - 1953. Detailed indexes of localities and rock names and a bibliography, with complete references, will be included. Interpretations will be based on the entire compilation. They will be published either with, or shortly after, the compilation.

#### PROCEDURE

I shall now take up our methods of procedure.

Our first task was the organization of files that would meet a number of requirements. First, they were to be as simple as possible. Second, they were to be adequate and flexible enough to take a variety

of information. Third, they were to yield the information quickly and easily, and in the form that might be needed.

We studied the system Washington had used,---a single card, 7.5 by 12.5 cm, for each analysis, using both sides,---the face for the analysis, the reverse for the norm calculation. As for filing, Washington arranged his cards geographically by country and locality and then by silica percentage. He then rearranged them as he desired for various purposes. We knew that this system would not meet our needs. Our final decision on a filing system was a four-part arrangement, each part of which is connected in some way with another part, so that no section is, as one might say, a dead end.

I will describe the file arrangement first and then show you how the parts of it correlate. The files consist of:

1. The periodical record. A single card, 12.5 by 20 cm, with appropriate lines, is used for each periodical or serial publication. The title, place and frequency of publication, and library where consulted are given at the top of the card. On the body of the card the results of the search are indicated. Each volume and number are recorded and if no material is found, a horizontal line is drawn in the appropriate column. If, however, analyses are found, then the name of the author is recorded together with the number of analyses and a check mark when these analyses have been entered in the files. In our search of the literature we are also recording the occurrence of analyses of sedimentary rocks. These are indicated by the letter s in parentheses in one of the columns. The periodical record cards are filed according to the country of publication.

2. The second part of the files is an author record. This is a small card, 7.5 by 12.5 cm. One card is made for each article or book from which analyses are selected. At the top of the card is given the complete citation, that is, author's name, title, periodical name, volume, pages, and year. Farther down on the card are given the rock names, the number of analyses, country, and silica percentage of each. This file is arranged alphabetically.

3. The third part of the file is a geographic record. This is also a small card, 7.5 by 12.5 cm. One card is made for each locality for which an analysis is recorded. The locality is given by country first, and then more specifically with latitude and longitude coordinates. For cross reference, the author, year, and rock name are also given on this card. The file is arranged by country.

4. The fourth part of the files is the rock analysis record. One card, 12.5 by 20 cm, is used for each analysis. The format of this card has been carefully worked out and was tested by actual use before we had it printed. The face of the card contains the analysis, the calculation, the norm, and such data as name, locality, analyst, age, occurrence, mode, rating and classification. The reference and additional data are placed on the reverse side. The analysis cards are the only part of the file to be made in duplicate,---one for permanent filing before the norm is calculated, the other for the calculation and transfer of information to the punch cards. The analysis cards are arranged by silica and alumina percentages. This seemed to be the most useful method and experience so far has proved it.

One other file will be kept. This is a file, by authors, of books or non-periodical publications that have been searched and rejected. Our author file will contain references to books from which analyses are taken, but without a reject file we would have no record of books that had been examined and which contained no material.

The file arrangement that I have just described facilitates the locating of an analysis in any one of several ways. Given the periodical, author, or locality, one can proceed from any part of the file to another part. Each locality card gives the author reference and rock name. Each author card gives the complete reference, country, rock name, and silica percentage. The periodical record gives the authors' names. As the amount of data compiled increases, the usefulness of an interdependent file should also increase. No file of rock names is maintained at this time for it does not seem practical.

After organizing our filing system, the next task was to assemble a list of periodicals and serials to be searched. In this task, we have been fortunate to have several sources of useful material at hand. Washington's accurate record of the literature he examined is published in Professional Paper 99. This was used as a starting point. We have had full access to the list of serials used in the preparation of the Bibliography of North American Geology. Miss Marie Siegrist, in charge of bibliographies prepared by the Geological Society of American, has given us full use of her catalogue. I, myself, had compiled a list of publications in connection with my work in our State Department during the war. From these sources we

have compiled a list of approximately 1500 publications that are likely to contain articles with rock analyses. Washington's list contained 313 serials. Our list is about 5 times as long. This represents the general increase in scientific publication throughout the world, the inclusion of a greater number of Russian publications, and an expansion of the type of literature to be searched. This last point is important, for it reflects the fact that rock analyses are appearing in a greater variety of publications than previously. This is most likely the result of both an increased amount of analytical work and the need for a publication outlet.

A comparison, by continent, of the number of periodicals in 1914 and 1953, shows the following:

	1914	1953
North America	78	350
South America	4	85
Europe (except Soviet Union)	168	657
Asia (except Soviet Union)	14	141
Soviet Union	9	163
Africa	11	102
Australia and New Zealand	<u>29</u>	<u>69</u>
	313	1567

An examination by place of publication, of our present list, shows the largest percentage in Europe and the next largest in North America. The figures are:

	<u>Percent</u>
Europe	42
North America	22
Soviet Union	10
Asia	9
Africa	7
South America	5
Australia and New Zealand	5

In addition to assembling the list, we have notes on the availability of these publications at the library of the U. S. Geological Survey and at the Library of Congress. Particular attention has been given to the holdings of Russian periodicals because of the very erratic distribution to libraries.

#### COMPILATION PROGRESS

Upon the completion of the periodical list, the actual work of examining the periodicals, and selecting and compiling the analyses was started.

Africa was chosen as the first area to receive our attention. This was not a random choice. We knew that a large proportion of the African literature had been initiated since 1914, as shown by the 11 publications at that time compared with 102 at the present time. A good part of the publication increase has been the result of the organization of colonial surveys after World War I. The literature is not so voluminous but that a large number of several types of publications could be covered in a reasonable period of time. We thought this might give us fairly quickly an idea of unforeseen problems that might arise in the course of the work. We knew that a fair amount of analytical work had appeared in these publications so that we were assured of material. Also, we felt that the language problem was not a major consideration and would not delay the work unnecessarily.

There are 40 individual political entities in Africa, classified as republics, colonies, territories, trust territories, native territories, possessions, mandates, dominions, and protectorates. Of these 40 entities, 14 have no publications that are of interest to our work. Eight others have 12 publications that were examined, but they yielded no material. This then reduces the number of countries in which we are interested to 18, slightly less than half the total.

The publications of 14 of these 18 countries have been completely examined. The number of publications is 62. The publications of the other 4 countries, have been partially examined. They number 28, of which 11 have been finished and 17 remain to be done.

The total number of periodicals for Africa is 102, of which 83 percent have been examined.

Eighteen countries have publications that contain rock analyses. For ten of these countries, (Gold Coast, Kenya, Nigeria, Sierra Leone, Tanganyika, Uganda, French Equatorial Africa, Nyasaland, So. Rhodesia, Basutaland) the publications have been examined, the analyses have been examined, the analyses have been selected, and the appropriate records made for each part of the file. There are 35 publications, and 354 analyses have been selected and recorded.

The publication of Belgian Congo, French West Africa, Egypt, and Morocco have been completely examined and all the analyses noted, but not all have been recorded. From 27 publications, 47 analyses have been recorded and 390 remain to be added to the files.

For the remaining 4 countries, Algeria, Tunisia, Madagascar, and the Union of South Africa, there are 28 publications which have been partially completed. From the 11 that have been searched, 71 analyses have been recorded. It is difficult to estimate the number remaining in the other 17 publications, but there might be about 300.

Altogether, from the completed periodicals, 472 analyses have been recorded. Eight more from a separate reference brings the total to 480. Of these, 364 or 76 percent, are igneous. Except for the one separate reference just mentioned, we have not taken into account the rock analyses that appear in books published apart from the periodical literature. For Africa, this is not a problem because most of the books are published in Europe. Our present plan of procedure is to keep a record of all such books that are brought to our attention, obtain other references from Mineralogical Abstracts and similar sources, and eventually do them too.

Adding the 480 analyses that we have in the files now, the 390 that we have selected, and the 300 that we have estimated gives a total of approximately 1170 analyses that will have been taken from literature published in Africa. Although the African literature is estimated to be 7 percent of the world literature, we have not completed 7 percent of the ultimate number of analyses. Only about one-half of the publications searched have yielded material. In addition, it must be remembered that many of these publications have been in existence for only a portion of the 40-year period since 1913. Neither does the figure represent, by any stretch of the imagination, the total number of analyses of African rocks that we will eventually compile because many of these analyses are to be found in the publications of

Great Britain, France, Italy, and Germany. We have found, however, with only a few exceptions, that the analyses in the African periodicals are analyses of African rocks, and also that the publications of any one country usually contain analyses of rocks of that same country. From this point of view, the African literature might be termed a strictly regional literature. Within each country, the analyses frequently group themselves by districts, as might be expected. The analyses from Southern Rhodesia account for about one-third of the files at present, and they represent well-known districts, such as Hartley, Gwanda, Gwelo, Mazoe, Untali, Belingwe, and others. For the Gold Coast colony, the Obuasi, Birim, and Tarkwa gold districts are well represented. Other areas are the Osi area in Nigeria, the Chilwa district in Nyasaland, the Njombe district in Tanganyika, and the classic Bufumbira and Mt. Elgon areas in Uganda.

#### PROBLEMS

We have encountered no major problems so far. There are several minor ones that I should like to bring to your attention because they concern the extremely important matters of care and accuracy, not only in compiling analyses but in publishing and quoting them.

Surprising and amazing as it may seem, an unusually large number of published analyses have totals that are wrong. It is often impossible to tell whether a wrong total is the result of erroneous addition, a typographical error in one of the figures, or perhaps a deletion or addition of a determination at the last moment. In recent work, corrections can be ascertained by writing the author. In the

earlier work, it is commonly impossible.

Too many times errors are introduced in quoting analyses for comparison. We had occasion to note recently that errors of one kind or another had been introduced into eight out of nine quoted analyses in one paper. On further inquiry, we found that the author had not even noticed his mistakes until we brought them to his attention. At the present time, however, he feels very sad that they are in print. When corrections are introduced deliberately in a quoted analysis, with no explanation, there is no way of knowing whether it is a correction or an error. Any changes made in quoting an analysis should always be accompanied by an adequate explanation.

Often, too, analyses are quoted with no indication that they are not original. And again, they are quoted and indicated as such, but with no information as to the source.

Our policy, in the compilation, is not to use quoted analyses, but to record the analysis from the first published reference. We have found that laboratory specimen designations or analysis numbers, given with an analysis, have been of great value in sorting our quoted analyses, for in many instances a rock acquires a different name and even a differently described location when it is quoted.

When I talked with Professor Niggli, he mentioned two points that the thought should be brought to the attention of this group. The first point was the importance of compilations on a national basis and the hope that more of them would be undertaken. We have found the two compilations in the African literature, those of Uganda and Southern Rhodesia, indispensable. Professor Niggli's other point was the hope

that others would follow our procedures, thereby attaining some degree of uniformity.

I should include a few words about the future. After publication, and even before, we hope to make the files a continuing, growing, and useful adjunct to petrologic work. We hope that you will contribute to the file and we, in turn, will give you material that may be useful in your research.