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Selective Geologic Map Information

A computerized file system for state geologic maps has been developed by the U. S. Geological Survey.

Abstract: *For the past several years, the U. S. Geological Survey has been installing many of its research files in computer-based data banks. One such program has been assigned the task of implementing computer-assisted mapping techniques in the updating of geologic index maps. The data files for these maps are designed to perform multiple functions, some of which are directly applicable to land-use planning and management. One purpose of this project is to provide selective display of index-map data, both text and graphic, interactively. Another aim is to assist the map designer who is concerned with the clear display of multi-level information. The program can furnish management with a tool for the assessment of present data and the practical future allocation of resources.*

Introduction

One of the projects of the U. S. Geological Survey is the provision of computer-assisted methods for updating geologic index maps. Some functions of this project are of interest to land-use planners.

The geologic index maps supplied by the U. S. Geological Survey have traditionally shown all published geologic maps that are of general interest. These maps are not restricted by area of coverage, by scale, or even by publisher. Thus, these indices are representative of the entire spectrum of geologic mapping. In the past these index maps have been published on a state-by-state basis, usually at a scale of 1:1,000,000.

The geologic index map (Boardman and Smysor, 1959) is, indeed, both a map and a reference list (Figure 1). Each outline and/or discrete point, depending upon the scale of the original map, represents the area covered by a published geologic map. Each outline or point on the map has an alphanumeric identifier which corresponds to a number on the numbered list of bibliographic reference materials on the map. In the past, this list has included author, title, scale, publisher, series, and year. Now that the transfer has been made to computerized files, the number of descriptive items has been increased. The new list contains the following information: identification number, State, authors, year, title, county or region, publisher, scale, series, emphasis, area of coverage, extreme north latitude, extreme south latitude, extreme west longitude, extreme east longitude, center point latitude and longitude, boundary identification, a list of other maps not included, availability of the map in the U. S. Geological Survey, base, geology or geochemistry, and plate numbers. The acquisition of some of this information by manual methods entails excessive effort. Similarly, manual methods produce results of uncertain accuracy, for example, the extremes of latitude and longitude. If the map information is in digital form, the computation of these values is relatively easy, and entails a transformation algorithm and some sorting. The scope of the retrieval criteria is greatly expanded by the introduction of such additional parameters.

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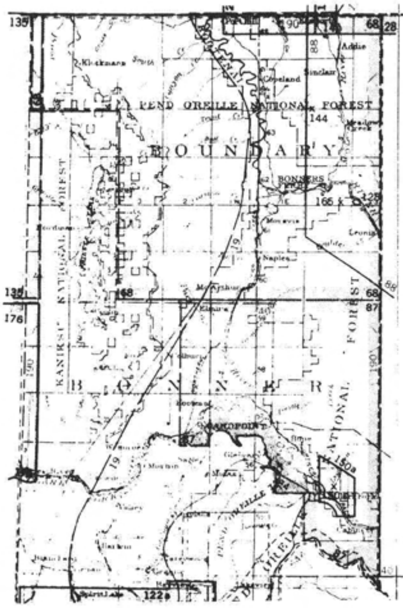

STATE MAP

Geologic map of Idaho, by C. P. Ross and J. D. Forrester, scale 1:500,000: U. S. Geological Survey and Idaho Bureau of Mines and Geology, 1947.

KEY TO INDEX MAP

Many of the publication titles are abbreviated. The authors named are those credited for the reports in which the maps appear or, as noted, for the geologic mapping.

1. 1872. Hayden, F. V., Map of the sources of the Snake River: U. S. Geol. and Geog. Survey of the Terr. 1:316,800.
2. 1883. Hayden, F. V., Geologic maps of portions of Idaho, Wyoming, and Utah: U. S. Geol. and Geog. Survey of the Terr., 12th Ann. Rept., map case. (a) Sheet 2, 1:500,000; (b) sheets 4 and 5, 1:253,440. A. C. Peale, Orestes St. John, and F. M. Endlich.
3. 1895. White, C. A., Bear River formation: U. S. G. S. Bull. 128. Pl. 1, 1:1,140,000.
4. 1898. Lindgren, Waldemar, Boise quadrangle: U. S. G. S. Geol. Folio 45, 1:125,000. Same area as No. 12, Gold in Idaho, fig. 10.
5. 1898. Lindgren, Waldemar, Mining districts of the Idaho Basin and the Boise Ridge: U. S. G. S. 18th Ann. Rept., pt. 3, p. 617-744. (a) Pl. 87, 1:1,250,000; (b) pl. 96, 1:62,500; (c) pl. 97, 1:16,800; (d) pl. 98, 1:71,280.
6. 1900. Lindgren, Waldemar, Schrader, F. C., and Prichard, W. A., Gold and silver veins of Silver City, De Lamar, and other mining districts: U. S. G. S. 20th Ann. Rept., pt. 3, p. 65-256. (a) Pl. 9, 1:500,000; (b) pl. 17, 1:125,000; (c) pl. 32, 1:62,500, (same area as No. 12, Gold in Idaho, fig. 9); (d) pl. 8, 1:2,500,000.
   1928. Campbell, Stewart, A geologic error regarding the Wood River district: Eng. and Min. Jour., v. 126, p. 287-289. (e) Fig. 1, 1:125,000.
7. 1901. Lindgren, Waldemar, Gold belt of the Blue Mountains of Oregon: U. S. G. S. 22d Ann. Rept., pt. 2, p. 551-776. Pl. 64, 1:375,000.
8. 1901. Russell, I. C., Geology and water resources of Nez Perce County: U. S. G. S. Water-Supply Paper 53. Pl. 2, 1:937,500.
9. 1902. Russell, I. C., Geology and water resources of the Snake River plains: U. S. G. S. Bull. 199. Pl. 1, 1:2,112,000.
10. 1904. Lindgren, Waldemar, and Drake, N. F., Nampa quadrangle: U. S. G. S. Geol. Folio 103. 1:125,000.
11. 1904. Lindgren, Waldemar, Drake, N. F., and Schrader, F. C., Silver City quadrangle: U. S. G. S. Geol. Folio 104. 1:125,000.
12. 1904. Lindgren, Waldemar, Geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U. S. G. S. Prof. Paper 27. Pl. 1, 1:823,680.
    1946. Staley, W. W., Gold in Idaho: Idaho Bur. Mines and Geology Pamph. 68. Fig. 16, 1:1,125,000. Fig. 8, 1:312,500, is same area as No. 35; fig. 9, 1:85,000, is same area as No. 6-c; fig. 10, 1:250,000, is same area as No. 4; fig. 11, 1:250,000, is same area as No. 61; fig. 13, 1:312,500, is same area as No. 68; fig. 14, 1:312,500, is same area as No. 29-a; fig. 17, 1:312,500, is same area as No. 108-a; fig. 18, 1:750,000, is nearly same area as No. 34-a; fig. 19, 1:36,000, and figs. 20 and 21 combined, 1:24,000, cover areas similar to No. 69-b; fig. 22, 1:56,000, is same area as No. 115-a; fig. 23, 1:500,000, is nearly same area as No. 32.

FIG. 1. Portion of index to geologic mapping in the State of Idaho.

STORAGE AND RETRIEVAL SYSTEM

These index maps are particularly interesting as a problem in manipulating digital data files because the maps combine both text and graphic information. At present, strictly text-handling computerized systems ars abundant. Only a few systems, however, encourage the use of both text and graphics. The software storage and retrieval system used for these index maps is the Geologic Retrieval and Synopsis Program (GRASP). This program was developed within the Geological Survey by Roger Bowen and Joseph Botbol (in press). It is used extensively within the USGS and has been installed on a variety of computers within and outside the USGS. It is written in FORTRAN IV, which accounts for much of its portability and versatility. It can be run interactively or in batch mode. The system recently has been modified to support the manipulation of both text and graphic data, and is thus an ideal solution to the problem of displaying the information contained on geologic index maps.

DEFINED CONDITIONS

One of the major functions of the project is to facilitate the creation and updating of the map files. This task requires retrieval of specific items to expedite editing (that is, addition, deletion, and change) of the existing digital data. To meet this need, any or all of the previously listed descriptive items can be keys upon which to search the computerized files. That is, the descriptive items can be used in combination with each other to select only those references (text and/or graphics) that are of interest, and simultaneously to exclude all others. Subsequently, any combination of descriptive items associated with the selected reference can be retrieved and displayed.

The need for such selectivity is obvious from a land-use analysis aspect, where typically the total information available is overwhelming and only a small part is required for making any one decision. That small part is, however, of vital importance. This need for selectivity is exactly analogous to a USGS need to edit and update these files.

An actual example is presented in Figures 2 and 3, which show a query directed to the files for the State of Idaho. There are two search criteria: (1) those maps published in the year 1973, and (2) those maps at a scale less than 1:250,000. Two files are created, one for the first criterion, and one for a combination of the two. Four different items are extracted from the first file: (1) the numeric identifier, (2) the title (3) the author, and (4) the publisher. These examples have been taken directly from the computer.

Figure 4 shows the graphic information extracted from the second file, (geologic maps published during 1973 at a scale less than 1:250,000). Identification numbers are also plotted so that text and graphics can be

```
enter command: cond
A.  year eq 1973
B.  scale1 lt 250000
C.


enter command: logic
enter logic:   a


enter command: search
enter INPUT file name: indx16
enter OUTPUT file name: t1
all   296 records of indx16 searched.
        6 records found which satisfy the request.
they have been stored in t1

logic
enter logic:   a*b


enter command: search
enter INPUT file name: indx16
enter OUTPUT file name: t2
all   296 records of indx16 searched.
        4 records found which satisfy the request.
they have been stored in t2
sru's:6.2


enter command: list
enter name of file: t1
enter number of lines/page: 40
enter c for column or r for row printing: r
at each pause press cr key to continue. to abort enter a.
enter the names of items or the expressions which you want printed.
    1. id
    2. title1
    3. author1
    4. publish
    5.
```

FIG. 2. Example of a query directed to the files for the State of Idaho.

cross referenced. (Compare Figure 3 and 4)

Another very practical application is the combining of information from different files. For example the descriptive items are (a) the geologic maps of Idaho published in 1969 and (b) the nonferrous metal deposits in Idaho. The metal data are from a stored file composed of nonferrous metal deposits

```
id      =      287
title1  =reconnaissance geology of the selway-bitteroot wilderness
                                                  enter command:
author1 =greenwood, w.r.
publish =idaho bur. mines and geology
***********************
id      =      288
title1  =geologic map of the spokane quadrangle, washington, idaho,

author1 =griggs, a.b.
publish =u.s. geol. survey
************************
id      =      289
title1  =mineral resources of the idaho primitive area and vicinity,

author1 =cater, f.w., and others
publish =u.s. geol. survey
************************
id      =      290
title1  =mineral resources of the clear creek-upper big deer creek

author1 =cater, f.w.
publish =u.s. geol. survey
************************
id      =      291
title1  =preliminary geologic map and sections of the hawley mountain

author1 =mapel, w.j.
publish =u.s. geol. survey
************************
id      =      292
title1  =geologic map of the goat mountain quadrangle, lemhi county,
author1 =staatz, m.h.
publish =u.s. geol. survey
************************
```

FIG. 3. Computer printout in response to the query of Figure 2.

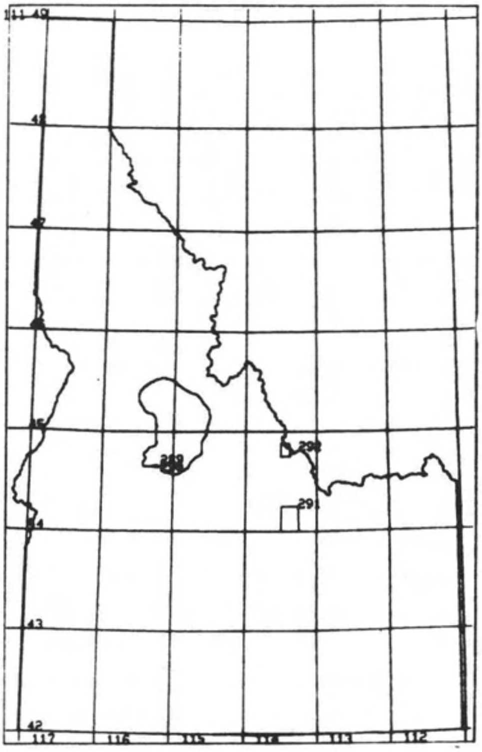

FIG. 4. Graphic output, year 1973, scale less than 1:250 000.

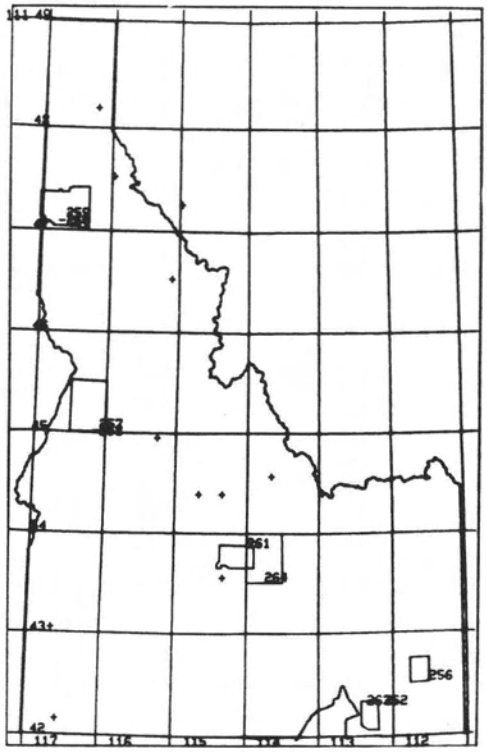

FIG. 5. Graphic output, non-ferrous deposits and maps for 1969.

of the world. The file includes an identification number and the position of the metal deposit given in degrees and minutes of latitude and longitude. The plot of the resultant of the two files extracted is shown in Figure 5. The crosses represent nonferrous metal deposits, whereas the geologic maps published in 1969 are outlined and accompanied with identification numbers.

UNDEFINED CONDITIONS

The preceding examples illustrate search, retrieval, and graphic output when well-defined search and retrieval criteria are known ahead of time. The increasing flood of information and publications makes it difficult to present all the information in a visually effective form. At the USGS, this is a problem of map design, but it might well be considered a general problem of spatial relationships.

To illustrate this situation, a file was created for geologic maps published for Idaho during 1965-1975. A simultaneous display of all 55 maps in this category would be virtually unreadable without special treatment for the graphic display. By diminishing image intensity, varying line widths, introducing patterns of broken lines, and adding color, the base information becomes unobtrusive but distinctive on a published map. Hence, these base-map features are not a problem. The attention here is focused on those primary map features outlined by the index map. Figure 6 is a plot for this file.

Obviously too many data exist, and additional considerations must be tested before a satisfactory map is made. Additional search conditions can be included until the resulting plot from the refined file is acceptable. Another approach is to enlarge a particular part of the graphic so that the detail can be seen more clearly. The area defined approximately by latitude 43.°5 to 45.°5 north and longitude 112.°5 to 114.°5 west was chosen because this portion of the graphic (Figure 6) is cluttered. Figure 7 is an enlargement of this particular area with additional detail included. The counties have been plotted and are shown by dotted lines. Figure 8 is an enlargement of part of Figure 7 from approximately latitude 44.°0 to 45.°2 north, and from longitude 112.°7 to 114.°0 west. All the uncertainties have now been resolved, and a new unique map has been created.

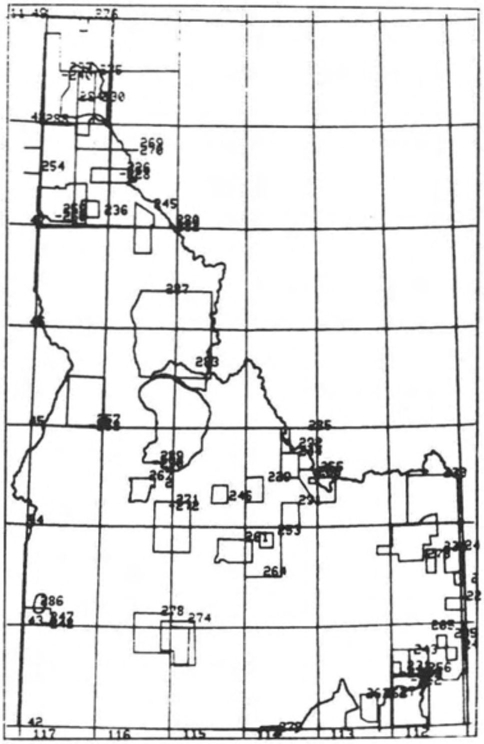

FIG. 6. Graphic output, maps for 1965 to 1975.

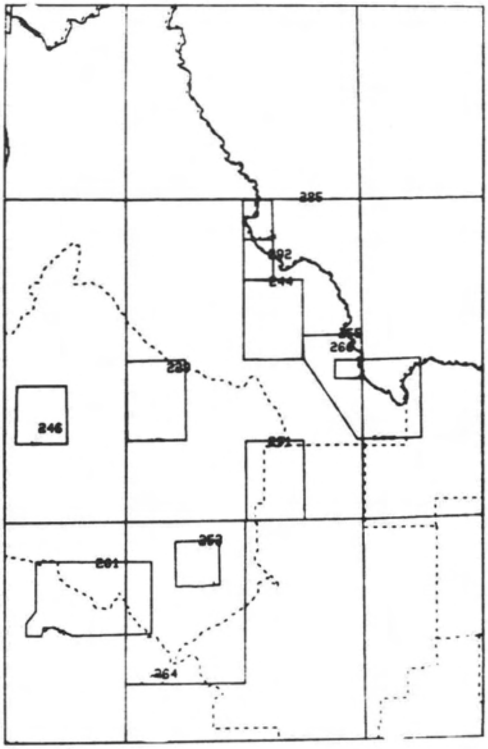

FIG. 7. Graphic output enlarged, maps for 1965 to 1975.

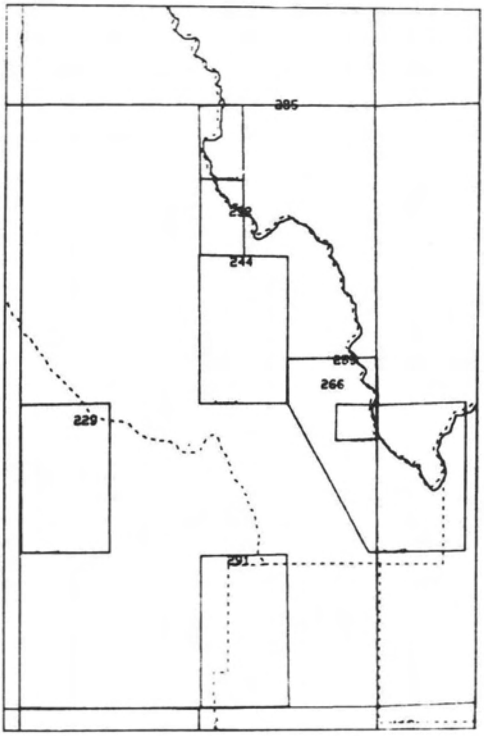

FIG. 8. Graphic output twice-enlarged, maps for 1965 to 1975.

The preceding examples and figures were computer generated using real data. The computer accesses were done "on-line" to actual data files of both graphic and text information. The illustrations were plotted interactively on a Tektronix 4014-1.

SUMMARY

A new computer data base at the USGS allows one to create maps either on preestablished criteria or on criteria developed through interaction with the data base. Both of these situations arise frequently in both land-use analysis and map making. This system is useful for the inventory and evaluation of existing information. The results from such assessments will assist in the future planning for the allocation of resources.

REFERENCES

1. Boardman, Leona, and Bettie Smysor, 1959, Geologic map index of Idaho: rev. ed., Washington D.C., U.S. Geol. Survey, (Originally compiled by Leona Boardman, 1949; revised by Bettie Smysor).
2. Bowen, R. W., and J. M. Botbol, in press, The Geologic Retrieval and Synopsis Program (GRASP): U.S. Geol. Survey PP.