

NFW TRENDS IN MAPPING

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The relationship between geography and mapping has always been close. In fact the original name of the Topographic Division of the Geological Survey was the Geographic Division, and the head thereof was known for several decades as Chief Geographer. Furthermore, three of the four great surveys that preceded and which were unified into the Geological Survey were titled Geographical Surveys. These surveys are most commonly known by the names of their leaders: Wheeler, Powell, Hayden, and King; but their official names were: Geographical Survey West of the 100th Meridian (Wheeler's), Geographical and Geological Survey of the Rocky Mountain Region (Powell's); Geological and Geographical Survey of the Territories (Hayden's); and Geological Survey of the 40th Parallel (King's). History proves these were truly four great surveys. Over a period of about twelve years (1867-1879) parties from these Surveys mapped and classified a great deal of the topography and geology of the western region. By Congressional Act of March 3, 1879, they were combined into the U.S. Geological Survey with King as the first Director. King was succeeded by Powell a year later, and the golden days of the Survey began.

The production of maps, which is the job of a cartographer, topographer, photogrammetrist, surveyor, and engineer, is of considerable concern to the geographer. The production of special kinds of maps is a primary concern of the Geological Survey. The production of the National Topographic Map Series is the principal concern of our Topographic Division.

The content, scale, and quality of the National Topographic series has changed over the years. In fact, in Powell's day (1880-1894) its scale was 1:250,000 for the western part of the United States; 1:125,000 for rural areas, and 1:62,500 for urban areas. Their content was sketchy and the accuracy, by today's standards, was questionable. This odd scale series incidentally was derived by dividing each smaller scale by two; i.e., the 1:500,000 to 1:250,000 to 1:125,000 to 1:62,500 to 1:31,680.

Change in mapping character has been very slow until recently. For example, although the Geological Survey was created in 1879, twenty years elapsed before the Survey dropped the 1:250,000 scale series, kept the 1:125,000 and 1:62,500 series, and picked up a new 1:31,680 series for urban areas. It took another thirty-five years to eliminate the 1:125,000 scale. The 1:62,500 scale has been retained. The 1:31,680 scale was changed to 1:24,000 after World War II; however, even today, the scale of 1:15,840 (half of 1:31,680) is occasionally encountered. Content and accuracy changed over this period of time, too, though it was gradual and inconsequential compared to later changes (except the early change in terrain registration from hachures to contours). Major Powell presented a plan to the Congress in the 1890's to complete the mapping of the U.S.; the requested \$10,000,000 for a period of ten years was never appropriated. In 1927, the Temple Act was passed to complete the mapping of the U.S.; again, the requested \$20,000,000 for a period of twenty years was not appropriated. At the end of World War II, the status of quadrangle mapping, at what was then considered acceptable standards, was 27% complete. In 1972, the status of quadrangle mapping in the U.S. was 52% complete for 7½' quadrangles and an additional 25% complete for 15' quadrangles (or, altogether, 77% complete). The only complete map coverage of the U.S. is at 1:250,000, not the series Powell started, but a new, post-World War II

series essentially designed by the Army and executed largely by contract. The series was turned over to the Geological Survey in the 1950's for maintenance and distribution.

Over the past 85 years, the single major purpose of the Topographic Division has been to compile and to publish the standard 1°, 30' or ½°, 15', and 7½' topographic map series in addition to the production of a few state maps, national park maps, and other special maps. The principal mapping objective of the Geological Survey for 85 years has been to cover the U.S. with standard topographic quadrangle mapping, little more, little less.

A recent project--the San Francisco Bay Region Study--is changing this old focus and effecting new trends in topographic mapping.

The San Francisco Bay Region Study was created by the Survey as an inter-disciplinary study to develop and to depict earth science data in order to allow more intelligent regional and urban planning in the Bay area. The Bay Area abounds in examples of disregard of local hazards such as seismic fault zones, plastic bay muds, landslides, floods, and so on. In order to provide the mapping tools considered essential to such a project, several new map products were conceived. Since the envisioned planning was to be regional, a scale of 1:125,000, to allow a regional overview, was selected. In addition, some products were produced at larger scales.

At that time, Interim Revision, a short-cut photo revision process, had just been developed by the Topographic Division, which was looking for meaningful areas in which to test the process. The San Francisco Bay Area had been included in an interim revision project several years prior to the start of the San Francisco Bay Region Study, thereby saving considerable time as well as providing local users of standard 7½' quadrangles with up to date map information instead of, in some cases, twenty year old maps. Interim re-

vision allows photo revision of all features that can be interpreted on an aerial photograph. Such features are necessarily planimetric and mostly cultural. No hypsographic revision is possible with this method. Since the primary purpose of the method is to reduce effort, thereby saving time and money, no field check was included, and, as a consequence, interim revised features might not be as accurate as the original features (plotted on the map and field checked). The interim revision was therefore printed in purple to distinguish it from the original, and perhaps more accurate, compilation.

The Survey was surprised to find an extra benefit of the purple overprint. Planners liked the purple representation of change between the original date of the map and the date of the interim revision. In fact they seemed to anticipate additional color overprints.

The color separation material of the interim revision 7½' quadrangles was reduced to 1:62,500 and mosaicked, and then further reduced to 1:125,000 to create the regional map. This map carries a complete pattern of streets instead of an urban tint. In fact, the predominance of streets in the urban areas created the effect of an urban tint, but still remained a valid street pattern. Since the contours and cultural detail, as well as the streets, are a reduction of their delineation on the 1:24,000 quadrangles, the usual generalization of detail normal to a 1:125,000 scale has been replaced by accurate and complete delineation of these features. This means more expressive contours and more cultural detail more accurately placed. Consequently, new regional interpretations are possible. Twenty-five to twenty-eight color separation plates were used to represent all features and colors on the 1:125,000 scale sheets so that a potential user could purchase numerous combinations of those best suited to his needs. This map has been a real "best seller" and is considered by many a collector's item, if not a work of art.

The Survey also created an orthophotomosaic at 1:125,000 from quad-centered photography flown at 40,000 feet. It is a companion document to the 1:125,000 line map. This mosaic was intended to show the myriad detail contained in a photo and not possible on a line map. It was not as successful as hoped, however, due primarily to varying reflections in the photographs. It did, however, direct the geologists' attention to several regional linear features that revealed structures hitherto undiscovered.

The production of the orthophotomosaic required the production of larger scale (1:62,500) increments suitable for mosaicking into the smaller scale mosaic. Fortunately, the photography was quad-centered; that is, each exposure centered over a standard 7½' USGS quad. The initial reason for this was economy; however, it also facilitated the production of the 1:24,000 orthophotos.

Although the quad-centered photography, flown at 40,000 feet, did not produce a sparkling 1:125,000 orthophotomosaic, it did produce high quality orthophotoquads. As soon as copies of these quads came to the attention of users, the demand for them soon outstripped photolab capacity, and large orders had to be discouraged. Although orthophotoquads were not a part of the original San Francisco project, they were soon added and their availability was possibly the greatest map contribution of that project. Two of the attractive features of the orthophotoquad are its relative cheapness (ca. \$300 per quad) and its quickness of production (months instead of years). Furthermore, the success of orthophotoquads on this project hastened their acceptability nationally and promoted, about a year later, an even larger project. In the fall of 1972, the State of Arizona and the Geological Survey commenced a project of two thousand 1:24,000 orthophotoquads for state-wide land use planning activities. This was the first large project that recognized the full value of this new product. Photography,

in this case, was U2 flown on quad centered flight lines. Again top quality quads were produced. It was largely these two projects that caused the Geological Survey recently to accept orthophotoquads as a standard product.

It must be evident from references above that another new and influential element in the field of mapping is improved photography, particularly at higher altitudes. Photography from 40,000 feet is quite common now, and from 50,000 to 60,000 feet is available. Once-over coverage of the entire conterminous U.S., from an altitude of 40,000 feet, has been considered for some time; however, budgetary reasons have delayed implementation. Of course, ERTS-1 has given us photography from even greater altitudes; nevertheless, satellite photography has been most useful in very small scale mapping such as 1:250,000 and 1:500,000 and studies dependent upon remote sensing.

Another new tool that accompanied the orthophotoquad is what was originally dubbed the orthophotopoquad, but which is now referred to more simply as the orthophotoquad with contours. This very useful product resulted from curiosity relative to the fit or register of the contour or hypsographic plate of a topographic map on a companion orthophotoquad. One must recognize that the production of a contour plate is usually the most expensive part of topographic mapping and that an orthophotoquad is normally without elevation data unless spot heights are added. If a contour plate exists for a quad, even though it be ten or twenty years old, the chances are its character is essentially unchanged due to the works of man. Or, even if hypsographic changes have been made, percentagewise they are minimal. Therefore in almost all cases a contour plate, even though old, should fit an orthophotoquad. The experimental combination fit perfectly and was immediately hailed by geologists as the best mapping tool yet devised for their studies, particularly in field operations.

An old handy tool that has always been rather "do-it-yourselfish" is a slope map. Nearly every student or practicing professional has had occasion to make a linear scale which, when laid across the contours of a topographic map, will determine terrain slope. By combining areas of equal slope into zones, one can produce a slope map. This is a laborious job fraught with countless human error possibilities. The Survey's objective was to automate the process to increase accuracy and to shorten the time of preparation.

After several false starts, the solution was found in a photomechanical process being used for other purposes. For several years, the photolab had been manipulating the line weights of original drawings to facilitate revision procedures and, more recently, to salvage compilation manuscripts for use as final reproduction materials. This was done by using a transparent spacer between subject and object films and by overexposing by a predetermined amount. The use of wider spacers, with an opal plastic overlay for a diffuser, provided line-weight changes great enough to cause contour lines to coalesce at a predetermined value of slope, thus creating solid areas identifying all slopes of the chosen value or greater. Later techniques included a revolving light source to widen the range of manipulation, and orbital movement of the film carriage, which may prove to be the most versatile method.

This procedure, utilizing new and still-experimental techniques, results in a considerably more detailed presentation of slope information than previous slope maps prepared by hand delineation. The added detail allows geologists and other earth scientists a fresh look at the terrain. Among other benefits, more precise tracement of earthquake faults and more accurate plotting of landslide hazards are foreseen.

Already, many requests for other slope maps have been received, and several have been produced. These include two-zone maps of twenty-five quadrangles for the San Diego

County Planning Department, and eight quadrangles showing six slope zones and covering about 450 square miles of the central and western Santa Monica Mountains--part of a cooperative program with the Department of the County Engineer, Los Angeles County.

Now underway is slope-map coverage of 2,700 square miles of the Bitterroot National Forest in Idaho and Montana for the U.S. Forest Service. And just beginning is the production of slope maps of the Phoenix-Tucson, Arizona Urban Pilot Project area, which may total more than one hundred $7\frac{1}{2}$ ' quadrangles.

These maps have been so useful that a standard series covering the U.S. has been suggested. Although such maps are useful in certain areas, the need for a national series, particularly when one considers the varying need for zone values by types of users and varying terrain, is doubtful. Customized slope map preparation may be the best answer to the users' needs.

Although large scale urban maps at 1:6,000 scale were suggested in the original San Francisco Bay proposal, they were canceled due to budgetary restraints.

At the time of the San Francisco Bay Region Study, the Topographic Division was experimenting with a new product called an orthophotomap. It differs from the orthophotoquad in line and in color. The orthophotoquad is black and white and essentially a photograph in appearance with some cartographic assistance; whereas the orthophotomap is essentially a line map with a photo background and a cartographic color assist in such areas as land, water, and foliage. An orthophotoquad can be produced independently of other mapping effort, but an orthophotomap is dependent upon the production of an orthophotoquad as well as the full range of mapping efforts. Consequently an orthophotoquad is produced relatively quickly and cheaply, but an orthophotomap is more expensive than a normal quad and requires considerably more preparation time.

The Topographic Division is now considering altering their standard map production procedure to allow the production of an orthophotoquad as an early product, a standard line map as an advance product, and an orthophotomap as a final product. The latter is to be produced only in those areas that warrant their production. Such areas are ones in which water features predominate. This procedure is termed phase mapping.

A new program and product that is in early stages of production is large scale urban orthophotomaps. In this case the new feature is the scale and contract execution. Two projects under way are at a scale of 1:2,400. One at Fort Wayne, Indiana, has 440 sheets, each covering a half section. The other at the same scale is in Charleston, South Carolina. Both of these projects are by commercial contract. Somewhat similarly, county format is being restudied as a possible new series.

Another new program on the horizon is metrication. The Survey has two series of maps now in the metric scale; they are the quadrangle maps of Puerto Rico and Antarctica. These admittedly are small programs; however, a third program will soon start in Alaska providing coverage for Anchorage and vicinity. The scale will be 1:25,000, with 5, 10, and 20 meter contour intervals. The bulk of the quadrangle maps of the United States (some sixty thousand $7\frac{1}{2}$ ' quads when complete coverage is accomplished) do not lend themselves to easy conversion to the metrical scale and obviously a patchwork of English and metric systems would be unthinkable. Like most other published scientific information, the Survey's maps will begin carrying duplicate values. When the eventual complete changeover comes, the principal problem will be the hypsography. Scales can easily be changed by photography, but contour lines in English units cannot be converted to metric, except by recompilation. Unfortunately the preparation of the contour plate is by far the most ex-

pensive of the five or six separate plates of a topographic map.

Another new horizontal program is digitization. Many maps prepared by other agencies, usually planimetric, are already digitized as are some contour maps. However, no program exists that will allow digitization and duplication of features of our large scale maps (notably contours) and maintain the map accuracy demanded by critical map users. The 1:250,000 map series of the U.S. is digitized allowing a computer-plotted production of maps at any desired scale within an acceptable range.

Development of a map-related digital computer-based information system is under contract with the Raytheon Company. The overall project is called NRIS (National Resource Information System). Eight agencies of the Department of the Interior are sponsoring the project.

The National Cartographic Information Office that will eventually replace the Survey's Map Information Office is progressing toward its goal of providing one stop service to a seeker of cartographic information generated by any agency of the Federal Government. Catalogues, browse files, ordering facilities, and expert assistance will be available so that a user can determine what is available, how it fits his needs, and how to order the materials directly. This will be done by combinations of microfilm in its various forms and computer storage and display systems.