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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 96

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MAP PRODUCTION METHODS IN THE GEOLOGICAL SURVEY OF CANADA

BY
G. S. DAUGHTRY

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GENERAL

The function of the Geological Cartography Unit is to prepare for publication, in the form of maps and illustrations, the results of the field and laboratory investigations of the Geological Survey of Canada. The staff of the Cartography Unit numbers 63 persons, distributed as follows: planning and supervision - 12; compiling and drafting - 42; photography and reproduction - 7; and clerical - 2. Two draftsmen, included in this number are attached to the Calgary office. The total strength of the Geological Survey is 418, of whom 196 are geologists and scientists.

The work of the Cartography Unit covers a wide range of cartographic techniques, the end results ranging from simple black-and-white text illustrations to large and complex geological maps containing as many as sixty distinct colour tints. The operation of the Unit can be divided into five categories, (a) Planning, (b) Compiling, (c) Drafting, (d) Editing, and (e) Photo-mechanical. The first four will be discussed in order; the Photo-mechanical processes, which include the use of the camera, vacuum frame, whirler, and proofing press are described in conjunction with the other phases of the work.

PLANNING

Base-maps for Field Use

The Cartography Unit is involved at an early stage in the planning of geological maps. A discussion between cartographic staff and field officers can aid in the selection of the base-map and the type of material to be used both in the field and in the office at the close of the field season. The Cartography Unit maintains liaison with the Surveys and Mapping Branch of the Department of Mines and Technical Surveys, and the Army Survey Establishment, the principal sources of the base-maps used in geological

mapping. On occasion, use is made of base-maps produced by provincial government departments.

Base-map manuscripts and negatives of published maps are made available to the Cartography Unit by the mapping agencies concerned in order that copies may be supplied to field staff on the desired scale (usually double the publication scale). By using the colour separation negatives of a published topographic map, any undesired feature of the base-map (e.g. contours, military grid, etc.) may be eliminated from the field map. Field maps are supplied on the following materials:

1. "Copyflex" prints - black-line paper prints, made by exposing to a positive transparency in the blueprint machine, and developing by a moist process. The scale factor is quite good but the paper quality and permanency of the image is poor. These prints are generally made from transparencies of manuscript base-maps, and are used for rough drafting in the field.
2. Vandyke prints - black-line paper prints, made by exposing to a film negative in a vacuum frame and developing in a water bath. The paper quality is good and the image is permanent, but due to the thorough wetting during processing the scale factor is poor.
3. Blue-lines on drawing paper - prepared by coating a sheet of drawing paper with a light-sensitive emulsion which is prepared as follows:

"A" Solution

Potassium ferrocyanide	141.75 grams
Acetic acid (28%)	2½ fl. oz.
or glacial acetic acid	.68 oz.
Water	80 fl. oz.

"B" Solution

Iron ammonium citrate	425 grams
Acetic acid (28%)	2½ fl. oz.
or glacial acetic acid	.68 oz.
Water	80 fl. oz.

The A and B solutions are mixed in equal quantities as required and applied by swabbing with cheesecloth. When the coating is dry the paper is placed in emulsion-to-emulsion contact with the negative in a vacuum frame and exposed to an arc lamp. After exposure the drawing paper is thoroughly washed in running water. The unexposed emulsion is washed away and the light-hardened image remains.

This type of field map has the advantage of providing a subdued base-map on which geological information can be plotted without interference from other detail; this is particularly desirable in areas of considerable relief, where contouring would tend to obscure geological data. The quality of the paper is excellent, and if an aluminum-cored paper such as "Pagra" is used the scale is constant. A less expensive but acceptable material is 2-ply "Strathmore" drawing paper, which may be rolled for transportation. The Pagra paper is more rigid, and is usually cut into sections of a convenient size.

4. Film transparency - made by exposing a matte-surfaced sensitized film such as "Cronaflex" or "Kodagraph" to a negative in the vacuum frame, and processing as a photographic material. This material is stable as to scale and has a surface which accepts either pencil or ink.

A variation of the transparent copy is prepared by coating an unsensitized drafting film in order to obtain a blue image of the base-map.

Field officers are supplied on request with a transparency identical with their field copies, on which they may prepare the final draft of their geological map. From the completed transparency black-line prints are supplied for hand colouring as a guide to the draftsman. The transparency is later used as an original from which the drafting medium is obtained.

Geological Manuscripts

When map manuscripts and copy for illustrations are submitted to the Cartography Unit by the Geological Manuscripts Section the overall treatment of the

job is planned. Decision is made as to the type of drafting to be employed, i.e. pen-and-ink drawing, positive scribing or negative scribing. The manner in which the base-map is to be reproduced is chosen from several alternatives. In the case of a multicoloured map in the standard series it is customary to make use of the existing topographic base-map whenever possible. However, the fact that geological maps are issued on inch-to-mile scales and topographic maps on fractional scales results in reduction of the base-maps. In the transition from 1/50,000 to 1 inch to 1 mile this amounts to 20 per cent. The effect of this reduction on the quality of linework and type must be foreseen, and corrective steps taken if necessary. The scale of 1 inch to 4 miles and 1 inch to 8 miles is so close to that of the 1/250,000 and 1/500,000 topographic maps respectively that no problem exists in the conversion. If a topographic base-map is unavailable or unsuitable for the geological map a base-map must be drawn, usually from a topographic manuscript map.

If the desired manner of presenting the geological information is unusual, the author and geological editor are consulted at the planning stage in order to determine the feasibility of the innovations. Not only cartographic but also the lithographic problems would be discussed.

The figure illustrations to accompany a report are inspected and a breakdown into text figures and larger items for insertion in a pocket in the report is supplied to the Editorial Division to assist in estimating publishing costs. Text figures are printed by the publisher from drawings prepared in the Cartography Unit, while pocket figures are produced entirely within the Department and supplied to the publisher for insertion in the report. Priorities are set at the planning stage so that progress on maps and illustrations may keep pace with the editing and printing of reports.

Because of a large backlog of work, certain maps and illustrations are selected for drafting by commercial firms under contract. The bulk of aeromagnetic maps are now produced in this way, as well as a new series of geological compilation maps on the scale of 1:1,000,000.

COMPILING

General

The setting up of a compiling group within the Cartography Unit is a recent innovation, designed to fit in with the trend toward specialization in the cartographic field. The job specifications for draftsmen in the Canadian Civil Service assume that the draftsman works from a manuscript copy accurately compiled as to content, and with geographical names brought up to date. In other large mapping areas, such as the Surveys and Mapping Branch, the Marine Sciences Branch, and the Army Survey Establishment, the compiling and drafting functions are completely separated, while in the Geological Survey they are combined in the Cartography Unit.

Base-maps

While the compilation section of the Cartography Unit deals primarily with the copy submitted for drafting, it may also be involved in the preparation of base-maps when none is available on the scale required. If base-maps on a larger scale are available covering the proposed map-area, a projection is constructed on a drafting medium, and the base-maps are reduced photographically to precise scale so that they will fit into the new projection. The negatives are then joined and a blue-line impression is laid down on the drafting surface. The information appearing on the blue-line is re-drawn, judgment being exercised in the degree of generalization suitable to the compilation scale.

If the detail on the large-scale maps is so dense as to be illegible after reduction, the generalization may be carried out by making tracings showing the selected detail and reducing them to fit the projection.

Review and Design

The compilation of a geological map or figure illustration is largely a problem of design and presentation. The original copy, representing the work of over one hundred geologists is naturally varied in character. Members of the compilation section study the copy thoroughly, cross checking between map, legend, and descriptive text. The symbols are altered when necessary to conform with standard practice, but new symbols may be introduced when deviation from standards is justified. The legend is arranged in its final form. The descriptive text is scanned for references to information displayed on the map or illustrations, and geographical names are checked for accuracy. New names proposed by the author are submitted to the Toponymy Division of the Geographical Branch, and through them to the province concerned, for approval. When proposed names are rejected, alternatives are usually supplied by the province, and the text must be altered accordingly.

In the case of figure illustrations the compiler must often consult the author in order to gain a thorough understanding of the purpose of the illustration. The original copy is then brought photographically to a scale suitable for drafting, and the compiler prepares a layout sketch, suggesting line-weights, and styles and sizes of type. This often involves the compilation of a small base-map and the transfer of the geological information.

Preparation of Drafting Media

When compilation is completed, and all points requiring clarification have been cleared with the author or geological editor, the next step is to supply the drafting

medium to the draftsman. From the negative of the geological compilation, which has been reduced to fit precisely the negatives of the topographic base-map, a blue-line key is printed on either Pagra paper, mylar drafting film, or scribecoat. The method of applying a blue-line image to paper has already been described. The emulsion used for drafting film and scribecoat is a bichromated albumen dye, available commercially in a wide range of colours for either hand or whirler application. The dyes used in the Geological Survey are known as "Water-kote" and are applied in the whirler. A hand-applied dye, obtainable from the same supplier, is known as "Kwik-kote". The drafting film, which has a matte surface on both sides, is coated with the dye, and when dry is exposed in contact with the right-reading side of the compilation negative. After exposure the film is developed with a mild ammonia solution and washed with a spray of water. Since the blue key is on the under side of the film it is not affected by erasing during drafting. Negative-scribing materials also carry the image on the under side, while on white scribecoat the key is on the drafting surface.

DRAFTING

General

As stated previously, drafting may be done by pen-and-ink or by scribing methods. Scribing has largely replaced older techniques in most mapping agencies because of the many advantages it offers. In the Geological Cartography Unit it is still the practice to give new employees some training in pen-and-ink drawing because it is felt that a greater appreciation of the standards required is gained in this way than by learning only the more mechanical scribing technique.

Scribing

Equipment

The scribing medium is a mylar sheet, preferably .0075 inch in thickness,

to which has been added a coating which can be removed by the scraping action of a scribing tool. The coating may be actinically opaque yellow, rust, or transparent red for negative scribing, or white for positive scribing. The scribing tools employ needles whose points are honed to produce a line of a specified thickness varying upward from as fine as .001 inch. For mapping purposes .004 inch has been found a satisfactory minimum. The points may simply be phonograph needles but excellent permanent points are available commercially in a full range of precise measurements. These points are made from carbon steel or synthetic sapphires, and require no sharpening. The sapphire point has the disadvantage of being fragile and requires care in handling. Points are available for cutting not only single lines but also double lines of varying thickness and spacing for roads, map borders, etc.

The tools into which the points are inserted are of several types. They are designed to rest on the scribing surface on smooth-tipped legs so that they may be easily guided with the hand. The point is inserted and locked in position so that with a normal pressure it will cut through and remove the coating without injuring the surface of the plastic. A rigid graver is used for cutting straight lines while a swivel graver, in which the point is free to turn, is used for cutting irregular and curving lines such as shorelines and contours. The points are interchangeable according to the line weight required. Other engraving tools are designed for specific tasks such as cutting building symbols, ruling lines with a straightedge, and cutting dots. Dot cutters may be simple hand tools in which the point revolves under pressure, or elaborate electrically driven instruments. Dot cutting is a major item in the scribing of geological maps, and an efficient tool is indispensable. Templates are available for cutting symbols, or can be made for special purposes.

Methods

It is most important that the coating be completely removed from the scribed lines. To this end a 40-power microscope is used to examine the work, and any loose particles of coating are cleaned off by wiping with facial tissue. The microscope is also used to check line thicknesses.

Negative scribing offers the advantage of producing an original which can be transferred directly to a lithographic plate without the use of a camera, the excellent quality of the scribed lines being maintained in the printed map. Names are set up in metal type and printed on both sides of thin acetate film (.001 inch) in perfect registration on a Vandercook proof press. Standard items such as geological symbols, reference numbers, etc. are set up in master sheets and photographed in a variety of sizes. From the negatives stripping film positives are made. The sheets of acetate or stripping film are thinly coated with wax in an electric waxing machine. A sheet of clear film of the same material as the scribing medium is registered over the scribed drawing on a light table, and the required names and symbols are cut out, affixed, and burnished down. It is important that the coating of wax be thin enough that no surplus wax oozes out around the type to collect dirt. The name overlays are converted to negatives in the vacuum frame.

In all processes where registration of multiple scribecoats and overlays is required, each piece of material is punched along one edge in a three-hole register punch. When two or more sheets are to be superimposed on a light table or in a vacuum frame the punched holes are fitted over a thin steel bar with three pins which fit the holes precisely. This ensures accurate registration of all components of a map.

The use of white scribecoat as opposed to the coloured variety involves a basic difference in procedure, being more closely related to pen-and-ink drafting. In

addition to scribed detail, symbols and type matter may be set on either acetate or thin paper and affixed with adhesive. If desired, items may be drawn on white scribecoat with ink. The completed scribecoat is backed with black cardboard and photographed as an inked drawing. Very complex maps may be scribed on an enlarged scale and reduced to publishing scale by camera.

For a draftsman trained in pen-and-ink drawing the transition to scribing is less difficult when the operation is in positive rather than in reverse.

Pen-and-ink Drafting

When drafting a map by pen-and-ink, aluminum-cored drawing paper is used when the line-work is to be printed in black only. When two or more colours are involved the medium most often used is Cronaflex drafting film, so that the various sheets may be registered on a light table. Inks specially designed for use on plastics are available. If the drawings are on publication scale they may be converted to negatives by contact, so that all type matter must be on acetate or stripping film. If a reduction by camera is necessary to bring the drawing to publishing scale, the type may be on either paper or transparent film.

Procedures

Some of the differences in procedure for the various types of maps should be noted, as follows.

Final Geological Maps

Final maps depict the geology in black lines usually on a base-map printed in three colours, i.e. black for culture, deep blue for drainage, and brown for contours. Rock units are distinguished by colour tints. If the negatives of a published base-map are available, positive films made from these become the "drawings" of black, blue and

brown of the base-map. All the marginal information appearing on the base-map is removed, to be replaced by the title, legend, descriptive notes, etc. pertaining to the geological map. Legends and descriptive notes are typeset. The drawing of the geology is registered over the transparencies of the base, and base-map names or contour numbers which conflict with geological type-matter are deleted and re-located.

If no published base-map is available, and the geology has been compiled on a transparency of a topographic manuscript map, the geological original is photographed to drafting scale. Blue keys are obtained on three sheets of drafting medium, one each for the black, deep blue, and brown, and drafting is proceeded with. The black drawing will include the culture of the base-map, the geological line-work, and the marginal information.

When drafting a geological map on which drainage detail is sparse, and no contours are shown, it is customary to draw both geology and base-map in black. Since geological colour tints are fitted to both geological contacts and drainage this type of map presents less problems in registration.

Preliminary Geological Maps

Preliminary maps are designed to be produced in the shortest possible time, and are printed either in black only or with geology in black on a grey base-map. Rock units are identified by numbers only; legends and descriptive notes are prepared by electric typewriter and reduced slightly by camera before applying to the map. The geological contacts are drawn in bolder lines than is the case on multicoloured maps.

The negative for a grey base-map is obtained by contact from combined positives of the black, blue, and brown negatives of the published topographic map. If the base-map is unpublished, the geological manuscript is reduced to drafting scale

and the complete map is drawn or scribed on a single sheet for printing in black only.

After completion of drafting, maps are checked by two supervisors for accuracy and adherence to standards, and if possible the author is given an opportunity to approve the drawing. The drawing is then photographed to precise scale, the negative is given a quality check and duffed and retouched where necessary. A vandyke print is made from the single negative of a black-only map or from the combined negatives of a black and grey map. This print is inspected as a final quality check and the negative is then ready for plating and printing.

Figure Illustrations

Large figure illustrations which are inserted in the pocket of a report are handled in the same manner as maps. In many cases they actually are maps, but are not classed as such because they are closely related to the text which they accompany, and separate copies are not available.

Figure illustrations are usually drawn for a reduction of 33 1/3%. Since the drawings are submitted to the publisher for reproduction it is most important that type be firmly affixed. The most satisfactory results are obtained by drawing on paper and applying paper type with a good paste. Hand-drawn patterns are preferred over adhesive pattern films for the same reason.

Aeromagnetic Maps

Until recently aeromagnetic maps were reproduced as blue-line maps on the blueprint machine. With an increase in the number of copies per map this slow method is no longer economical. Aeromagnetic maps are now lithographed with red aeromagnetic data on a grey base-map. Drafting methods are similar to those

employed for preliminary geological maps. The aeromagnetic compilation is supplied by the Geophysics Division of the Geological Survey.

Only a small number of aeromagnetic maps are now produced within the Geological Survey, while several hundred per year are flown, compiled, drafted and printed by commercial survey firms under contract to the Geological Survey.

Colour-negative Preparation

Colour Schemes

For multicoloured maps another major part of the drafting process remains. A colour scheme for the geological units is chosen which adheres to established conventions as far as possible, and which also maintains continuity of colour with adjoining maps. On small-scale maps such as maps of provinces or of the whole of Canada, the colour scheme is based on age, i.e. yellows for Cenozoic, greens for Mesozoic, blues and greys for Palaeozoic, carmines and purples for Precambrian, and strong tones of red, orange, and brown for intrusive rocks.

The Geological Survey policy is, however, to plan each map so as to display the geological information as effectively as possible, rather than set up a rigid colour scheme which might often result in maps which would be neither pleasing to the eye nor clearly readable.

The colour tints are obtained by combinations of solids and half-tones of four basic colours, yellow, carmine, blue, and grey, with the addition of bright red and deep blue where particular emphasis is required. In cases where the number of rock units exceeds the possible distinctive combinations of solids and half-tones, patterns are introduced, for example, blue rulings or dots on a white or light blue background. In this manner an almost infinite number of tints may be obtained without increasing the number of press printings.

Colour Guide Copies

Having established the colour scheme in consultation with the geological editor and/or the author, the next step is the careful preparation of a colour guide copy. If the map is to be printed by a commercial lithographer water colours are employed. An experienced draftsman can produce an excellent facsimile of the printed map which provides the lithographer with a clear and precise guide for the preparation of colour separation negatives. In the great majority of cases the map is printed within the department, and the colour negatives are produced in the Cartography Unit. The colour guide copy is prepared using coloured pencils, this method being much less time-consuming and sufficiently precise, considering that any points in doubt may be clarified by the author. The careful preparation of the colour guide copy is a valuable check on the accuracy of the drawing. For the colour copy, a print is made on either vandyke paper or matte-surfaced film. If the geology and drainage are on separate negatives these must be combined in making the print. A colour copy on film may be turned over and read in reverse, as a guide in making colour separation negatives which are reverse-reading.

Colour Separation Negatives

Peelcoat Method

The material most widely used in the preparation of colour separation negatives is a stable film coated with a soft red emulsion which can be peeled easily from the backing. This is available under various brand names such as "Peelcoat" and "Strip-kote", the former being in use in the Geological Survey at present. The peelcoat is coated in the whirler with a light-sensitive, water-soluble emulsion (deep-etch sensitizer) and exposed in the vacuum frame to a positive film (or combination of films) of the map. The unexposed coating is dissolved by swabbing with deep-etch developer,

and the resulting stencil of the image is etched by wiping with pure-grain alcohol on clean cheesecloth. The peelcoat is then flushed with water to remove all residue.

Pre-sensitized materials eliminate the coating operation, but are much more expensive initially.

A separate sheet of peelcoat is prepared for each colour tint required, and the areas to be printed in each colour are peeled from the appropriate sheet. For example, on the "solid yellow" negative all areas to be printed in solid yellow, solid green (yellow and blue), or any combination tint which includes solid yellow, must be peeled to produce an open "window" on the peelcoat. After peeling is completed all detail such as streams, names, etc. appearing as open lines on the peelcoat, must be opaqued to prevent their being printed in colour on the map. Peeling can only be done readily in areas surrounded by a solid etched line; dotted lines must first be cut with a lance to avoid tearing the coating. For this reason a special drawing of geological boundaries is sometimes prepared using only solid lines. This drawing is used for the preparation of peelcoats only.

Artificial Negative Method

One alternative process for producing open-window negatives is known as the artificial negative method. A right-reading key of the map is obtained on a sheet of .010 inch stable plastic (Dyrite), and working on the non-image side, all areas to be open on the colour negative are filled in with water soluble opaque. Care must be taken that the surface is completely masked with the opaque. When the opaque is dry the sheet is swabbed generously with a actinically opaque dye, and allowed to dry once more. Flushing with water then removes the opaque and produces an open window negative. This method is the most direct and economical in material, but the results depend on the skill of the draftsman in following the key while applying opaque in order to avoid overlaps or white lines between colours.

In order to avoid drawing precisely around water areas on each negative, a water mask is made by filling in all lakes with black ink on one sheet of dyrite. This sheet will be exposed in combination with each colour negative when making lithographic plates, so it is possible when opaquing the colour negatives to carry the opaque into the water areas.

A third method recently adopted eliminates the necessity for the separate water mask, which has the undesirable feature of adding an extra thickness of light-diffusing material between the negative and the lithographic plate when the plate is being exposed. In this method a sheet of matte-surfaced dyrite is placed over a positive film of the map. All areas to carry colour, i.e. all except water and blank areas are filled in with red opaque. One contact negative for each colour tint is made from this master. On each negative the areas not carrying the specific colour are filled in with opaque, thus creating an open-window negative for each colour tint. Besides eliminating the water mask, this method provides all negatives for the job on identical material, an aid in maintaining registration.

Colour Proofing

Following the completion of colour negatives a plastic colour proof is made. This proof is a close approximation of the lithographed map, and provides the final opportunity to check the work before plating.

The proof is made by coating a sheet of white plastic with Water-kote of the desired colour, and exposing to a negative in the vacuum frame. The unexposed dye is washed off in ammonia solution and the plastic is coated with the next colour. The process is repeated until each negative has been exposed to the sensitized plastic. Negatives for half-tones are exposed in combination with a 100-line ruling screen producing a 30 per cent tint.

EDITING

While editing might be considered to include the checking of map drawings by the supervisors, the term is more specifically applied to the critical examination of the colour proof by a senior member of the staff who is not involved in supervising the production. This check affords the first opportunity to view the sum of the various components of the map, which have up to now been seen as individual items. If progress checks have been thorough, few errors or omissions in drafting should be found at this stage, so the most detailed examination is directed at the colour separation phase. However, each part of the map can now be seen in its relationship to the whole, and possible improvements in presentation may be suggested. Corrections to the line drawings are made on the negatives unless they are of a major nature, in which case the drawings are corrected and re-photographed. Corrections and additions to names or other type matter are carried out by photographing the new items on stripping film, which is applied to the map negative with wax. It is sometimes more feasible to photograph corrected items in the margin on the same material as the map negative, and insert them in position with polyester tape. Errors in colour separation negatives are corrected by opaquing for deletion of colour or further peeling or scraping for addition of colour.

If possible the author is given an opportunity to examine the colour proof. When all corrections have been completed and verified by the map editor, the negatives and proof are sent to the Surveys and Mapping Branch for plating and printing.

This final stage in the production of a map is described in a booklet entitled "Manual of Map Reproduction Techniques" by E. D. Baldock, Chief Cartographer, Surveys and Mapping Branch.