DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/186

GEOLOGICAL CARTOGRAPHY OVERSEAS

by

P. A. Boekenstein

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SUMMARY

Five overseas cartographic establishments were visited for the purpose of studying the preparation of geological maps, text figures, and diagrams; the application of automation to geological map production; and drawing office organization.

United States Geological Survey, Branch of Technical Illustrations

1. Edited copy for maps and figures supplied at publication scale.
2. Maps scribed, and masks and screenmasters prepared in drawing offices.
3. All lettering by photomechanically prepared stripping film.

Canadian Geological Survey, Cartography Section

1. Maps and figures compiled in drawing office before editing.
2. Maps scribed, and masks and screenmasters prepared in drawing office.
3. All lettering by photomechanically prepared stripping film.
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1. Compilations supplied to drawing office at 6" to 1 mile for redrawing.
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1. 1:50 000 compilations supplied to drawing office for redrafting at 1:100 000 scale.
2. All maps hand-drawn in drawing office.
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INTRODUCTION

Three years ago I visited a number of overseas geological surveys in order to study their methods of geological map production. It was originally suggested that a draftsman from the Bureau of Mineral Resources (BMR) should visit the United States Geological Survey (USGS) after two of our geologists had studied their methods of editing and publication, and had been impressed by the efficiency with which multicolour maps and black and white text figures were produced. It was recognised that other geological surveys were also potential sources of information, and Canada, Britain, Germany, and Italy were added to my itinerary.

On the advice of a visiting professor from the Geology Department of the Imperial College of Science and Technology, London, I added the Experimental Cartography Unit (ECU) of the Royal College of Art, London, to my list. I was told that the ECU had assisted in many practical ways with the application of automation to mapping, and was at that time experimenting with digitizing geological information before producing a geological map by automated plotter.

All surveys were contacted and permission was requested to visit their cartographic offices and related areas. In all, my tour covered seven weeks; two were spent in the various offices of the USGS, which still remained my prime area of interest. The co-operation I received while visiting the various surveys left nothing to be desired, and I was gratified to find that most cartographers were as interested in BMR methods as I was in theirs.

Although the end results are much the same, each geological survey has evolved its own production system based on the availability of staff, access to photomechanical and other facilities, and, of course, finance.

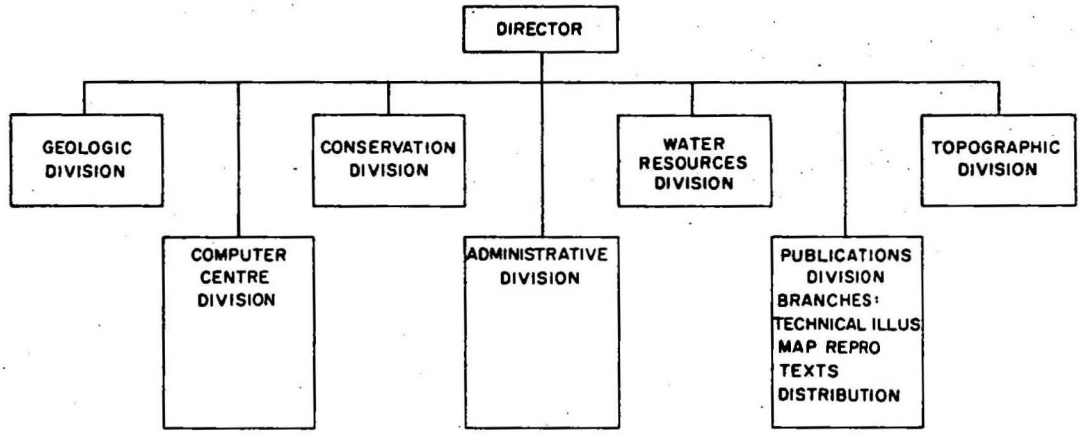

Fig. 1 Organization chart showing the seven Divisions of the USGS

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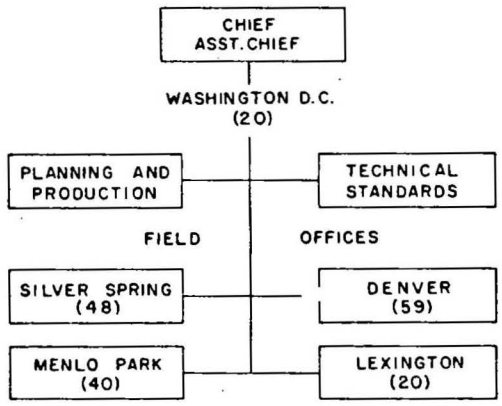

Fig.2 Sections of the Branch of Technical Illustrations, USGS

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The involvement of cartographers and technicians in compilation and production, and the duties they perform, vary from country to country, as do their status and career opportunity. The language barrier in non-English-speaking countries proved a problem, even when an interpreter was available, and it was not always possible to understand fully the individual and his feeling towards the work and the system.

Generally, I feel my questions received honest answers and that information was given freely. In several organizations, particulary the USGS, my progress through the various sections, and the way in which their methods and structures were explained, served further to illustrate their efficiency.

UNITED STATES GEOLOGICAL SURVEY: PUBLICATIONS DIVISION, BRANCH OF TECHNICAL ILLUSTRATIONS

The USGS (which forms part of the U.S. Department of the Interior) is divided into 7 divisions (Fig. 1). Map production, publication, and distribution are the responsibility of the Publications Division, which is subdivided into 4 branches, including the Branch of Technical Illustrations (BTI). The BTI, where all geological maps, diagrams, and figures up to plate-making are fair-drawn, has its headquarters in Washington, D.C., with field offices at Menlo Park, California; Denver, Colorado; Lexington, Kentucky; and Silver Spring, Maryland (Fig. 2).

Work flow

All geological compilation material for maps and figures (at publication scale) and text are prepared, edited, and approved for publication in the Geologic Division before being submitted to the BTI Washington

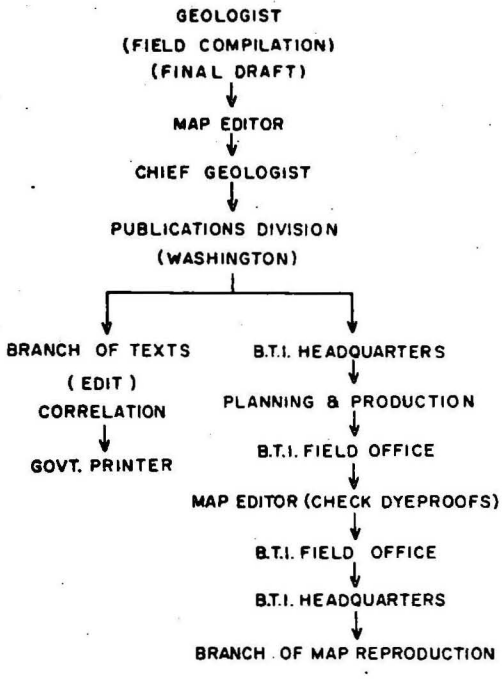

Fig.3 Work flow through the BTI, USGS

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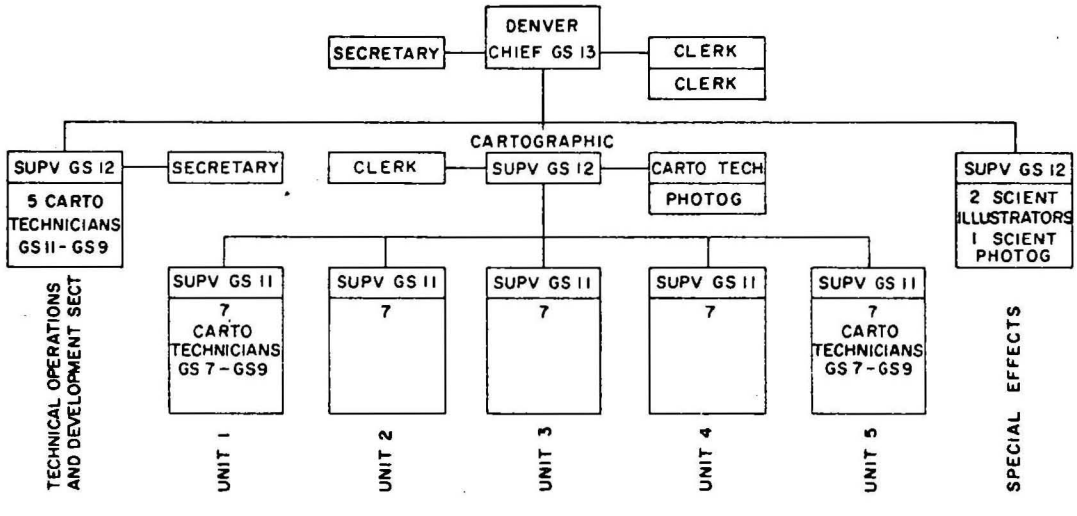

Fig.4 Typical structure of a BTI Field Office, USGS

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headquarters (Fig. 3). Here the Planning and Production Section assesses the project for time and cost, and feeds it to one of the field offices (preferably that nearest the author) for scribing, colour design, masking for colour separation, and preparation of screenmasters. After completion of the various cartographic processes, dyeproofs of the maps and figures are prepared, checked by BTI staff and Geologic Division editors, and corrected. Final copy (screenmasters, etc.), together with production times and costs, is returned to Washington headquarters, where printing is arranged through the Branch of Map Reproduction. Printing is supervised by the Technical Standards Section to ensure colour match, register, etc. Production times and costs are compared against those originally assessed in the Planning and Production Section, where comparisons are used to evaluate need for system modification or staff disposition and employment.

Field Office structure (Fig. 4)

GS numbers refer to gradings on the Federal Government salary scale, which ranges from GS1 to GS18; gradings GS12 and above are generally recognised as professional.

The five carto units are the production sections; all perform the same type of work, ranging from black and white figures to multicolour maps. There are usually 7 carto technicians and a supervising carto technician in each unit. Although the carto technicians are normally graded GS7 to 9, the gradings are elastic to allow semi-skilled people to be employed at GS3 or 4 level and promoted as their proficiency improves.

All maps produced in these units are scribed; lettering is on stripping film; negative masks are prepared on presensitized burn-out Peelcote; and negative screenmasters are made by applying portions of the

various percentage screens (at predetermined angles) behind the Peelcote masks. Field offices have access to photographic and colour-proofing laboratories (usually part of an adjacent Topo Mapping or Map Reproduction Branch), where scribe images, colour proofs, and burn-out masks are processed. Stripping film is ordered from Map Reproduction headquarters (Washington D.C.) where Photon and Fotosetter machines are located. Field offices have their own Headliners and Varitypers for smaller type-setting jobs.

Technical Operations and Development Section

Within the Field Office, this section prepares colour designs, conducts training, counsels and advises on cartographic methods, checks and reviews proofs and work standards, and explores new techniques. This section is also responsible for the supply of topographic and other base maps to the Geologic Division before field work starts.

Special Effects Section

This section prepares cover designs for publications, and non-standard figures and illustrations such as block diagrams, sections, photomosaics, and photo panoramas. It also produces lecture material such as slides and wall diagrams, and audio-visual material for staff-training programs.

Carto staff have a background of art training and are illustrators rather than straight carto technicians.

Equipment includes Statmaster (or similar) prism camera, Polaroid land camera, various movie and still cameras, tape recorder, enlargers, and darkroom facilities.

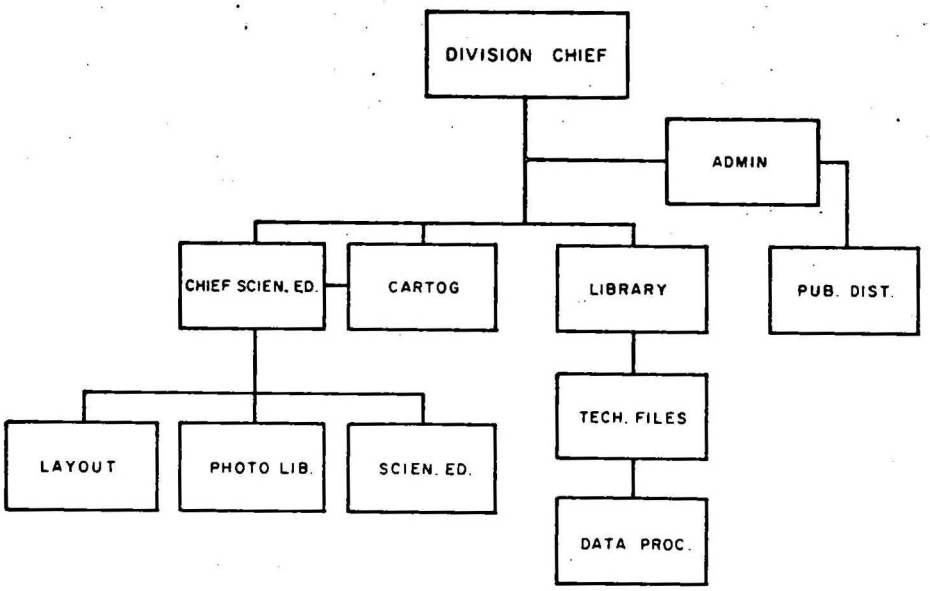

Fig. 5 Geological Information and Processing Division, C G S

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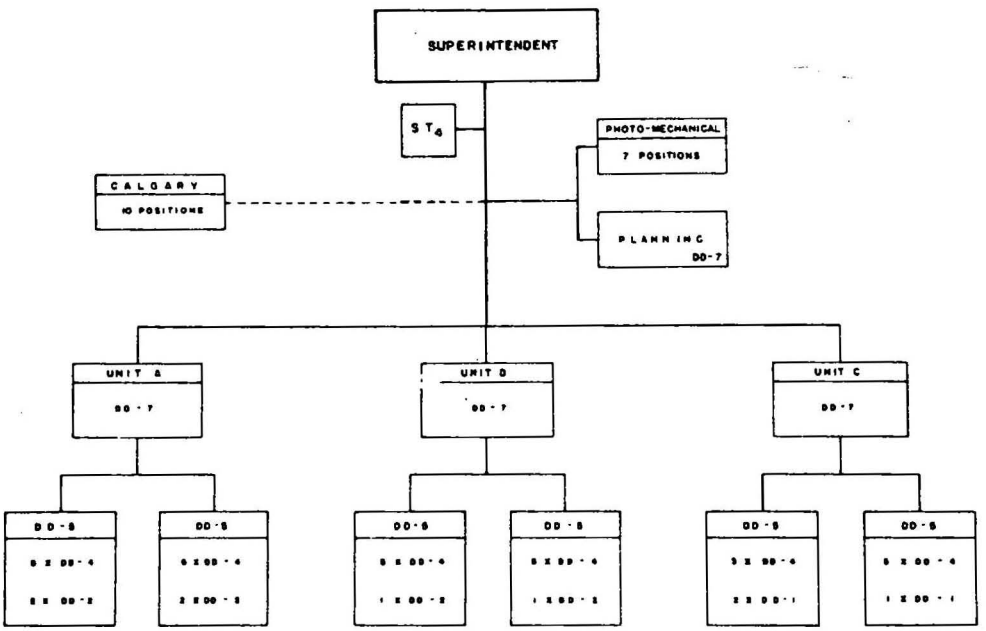

Fig. 6. Cartography Section, C.G.S.

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Careers

Carto technicians with ability and experience may reach GS11 level without formal qualifications (duties equivalent to BMR's Supervising Draftsman). However, consideration is given to anyone willing to undertake approved courses conducted by Government and other bodies. Advancement past GS11 into the professional area usually requires tertiary qualifications in addition to a cartographic background. Advancement to Branch head is possible.

Cartographer/Geologist relations

Good relations exist between carto staff, map editors, and authors, and it is evident that each has the greatest respect for the others, and the work they perform. Although material supplied to the BTI by the Geologic Division is edited, problems frequently crop up during the drawing and design stages; every effort is made to co-operate in order to keep delays and bottlenecks to a minimum.

CANADIAN GEOLOGICAL SURVEY: CARTOGRAPHY SECTION

The CGS forms part of the Department of Energy, Mines, and Resources, and has its headquarters in Ottawa and a branch at Calgary. Twelve months before my visit a major reorganization had been implemented in the editing and cartographic areas. An O and M committee had visited similar authorities in Canada and USA, and had recommended the formation of a Geological Information and Processing Division to include both areas (Fig. 5). They also recommended that the cartographic area should be organized similar to a USGS BTI Field Office (Fig. 6). DD numbers refer to draftsman grades in the Government salary structure; DD5 and DD7 have equivalent duties to BMR's Senior and Supervisory respectively.

DAILY TIME RECORD

DRAFTSMAN	UNIT	MONTH

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

	PROJECT DETAILS			ACTIVITY BREAKDOWN									
	JOB REFERENCE NO.	AUTHOR	ILLUSTRATION REFERENCE NO.	PLAN 1	COMP. 2	DRAFT 3	PATCH 4	CHECK 5	CORR. 6	PHOTO 7	COLOUR 8	MISC. 9	TOTAL
A													
B													
C													
D													
E													
F													
G													
H													
I													
J													
K													
M													
			ACTIVITY TOTALS (c)										

L	LEAVE	ANNUAL	SICK	SPECIAL	WP
S	GENERAL SUPERVISION				
P	PHOTOMECHANICAL NON-ASSIGNABLE				

DRAFTSMAN'S SIGNATURE	APPROVED	POSTED	TOTAL WORKING DAYS (b)

INSTRUCTIONS

1. Against the alphabetical listing, enter in sequence every job on which you work.
2. At the end of each day, enter in the appropriate date box the alphabetic code of the job(s) on which you worked during the day. Also, indicate by a numerical code the particular activity. Example: B^2 indicates the day was spent COMPILING the job listed against the letter B; D^5 indicates time CHECKING the job listed against D.
3. To record half days, divide the date box with a diagonal line then enter both halves. Example: 

   Note: Do not record periods of less than one half day.
4. Make an entry for each day of the month. Record non-working days, such as weekends and statutory holidays, by means of an X.
5. Record all leave by means of an L.
6. At the end of each month, complete the block under "Breakdown of Activities", as follows:
   (a) Against each job enter the total time spent on each activity;
   (b) Total the activity columns horizontally to calculate the total time spent on each job;
   (c) Total, the columns vertically;
   (d) Balance the vertical and horizontal totals to determine the number of direct mandays in the month;
   (e) Total the number of indirect and non-assignable hours;
   (f) Add the two totals together and enter the total number of working days in the month;
   (g) Sign the card and pass it to the supervisor for approval.

Fig. 7 Daily Time Record of the Cartography Section, C G S

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Cartographic methods

Whereas compilation, scribing, colour separation, and screenmaster preparation were previously carried out in different sections, it was suggested that each subsection of the 3 units should perform all cartographic functions. At the time of my visit some difficulty was being experienced as not all draftsmen were good compilers or scribers or both.

Although engaged in compilation, Canadian cartographers (unlike those of BMR) do not accompany geologists into the field, nor are their hand-drafted maps printed as Preliminary Editions. Instead the maps are edited and scribed before being printed in two or three colours.

Generally, a geologist's field compilations are submitted to the Cartography Section, where they are photo-reduced and recompiled at final publication scale; the compiling cartographer generalizes and allows for scale change. These compilations are returned to the geologist who submits them, along with the text, to the map editor. The maps re-enter the Cartography Section, where they are corrected, scribed, and colour designed, and negative masks and screenmasters are prepared. All photographic copy and colour proofs are made in the Photomechanical Subsection. Stripping film is prepared on photo-typesetters in the adjacent Surveys and Mapping Branch.

Not all geological maps are multicoloured. Frequently maps are printed in 2 or 3 'line colours' only, similar to BMR Preliminary Editions.

Control

A time/cost system (simplified from that used in the USGS) has been introduced. Each draftsman keeps a daily record listing the job, cartographic function, and time. These Daily Time Records (Fig. 7) are

CARTOGRAPHICAL JOB RECORD	UNIT	DATE REC'D.	JOB REFERENCE NUMBER
AUTHOR / SHORT TITLE			TYPE OF PUBLICATION

NO.	TYPE AND CONTENT	GRADE	MANDAYS		DATES			PRINTING - MAPS & POCKET [illegible]	
			EST.	ACTUAL	START	EST. COMPL.	ACTUAL COMPL.	SENT	RETURNED
1									
2									
3									

MONTH		DRAFTSMAN	1	2	3	4	5	6	7	8	9	TOTAL		DRAFTSMAN	1	2	3	4	5	6	7	8	9	TOTAL		DRAFTSMAN	1	2	3	4	5	6	7	8	9	TOTAL
TOTAL													TOTAL												TOTAL											

Fig. 8 Cartographical Job Record of the Cartography Section C G S

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TO DIVISION	SC. EDITING		TO CARTOGRAPHY	TYPING		PROOF		MS PAGES	PG. FIG.	PKT	MAPS
	& TO	FROM		TO	FROM	TO	FROM				

PG FIGURES		PKT FIGURES		MAPS		PRINTING		PKT SENT	10 FINAL	MONTHS
START	COMP	START	COMP	START	COMP	7 TO	FROM			TOTAL ELAPSED TIME ⇨

MONTH	PAGE FIGURES EST.			POCKET FIGURES EST.			MAPS EST.			MANDAYS		
	MANDAYS	CUM	4 %	MANDAYS	CUM	8 %	MANDAYS	CUM	0 %	PG-FIGS	PKT	MAPS
										TOTAL MANDAYS	X	RATE
										TOTAL CARTO. COST ⇨		0
										BOOK PRINTING		
										MAP PRINTING		
										OTHER		
										GRAND TOTAL ⇨		0

PROGRESS REVIEW (Offset)	AUTHOR	SHORT TITLE	DIVISION	PUB. REP. N°

Fig. 9 Progress Review Form of the Carthography Section, C G S

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transferred monthly to a Cartographical Job Record sheet (Fig. 8), which enables every project to be assessed for time and cost as a whole or for each cartographic function. Each project (from compilation to publication) is accompanied by a Progress Review Form (Fig. 9). This enables actual production times to be checked against those assessed when the job was first received.

Training

As in the USGS, cartographic training is conducted predominantly within the establishment. Some universities are conducting courses oriented towards cartography, and managerial and administrative courses are available from Government and other bodies.

INSTITUTE OF GEOLOGICAL SCIENCES, LONDON: GEOLOGICAL DRAWING OFFICE

This establishment has a staff of 29 and is divided into two Drafting Sections and a Photographic Section headed by a Chief Draftsman and an Assistant Chief Draftsman.

Compilation

Copies of Ordnance Survey topographic maps (6" to 1 mile) are supplied to the geologists as field sheets, and are submitted to the drawing office, where the geology is redrafted on plastic foil. The legend, letter symbols, etc. are photoset on stripping film and applied to the geology overlay. The resultant 6" to 1 mile maps may be reproduced by offset or dyeline according to demand.

Drafting at final scale and printing

The 6" to 1 mile sheets are photographically reduced to 1½" to 1 mile, and redrafted at 1" to 1 mile using an Ordnance Survey map as a

base. Geological detail is generalized under the author's guidance, and when the whole sheet is completed a colour design and guide are prepared and supplied to the author. Scribing was tried, but was considered to have no advantages because of the scale change during final preparation. Hand drafting has been retained, but hand lettering was replaced by photoset stripping film.

The map and text are finally submitted to the authors before being sent to the Ordnance Survey, where masks, screenmasters, a dyeproof, and finally a machine proof are made, and returned to London for checking before the map is printed.

Text figures

These are frequently multicoloured and are prepared in a similar manner to the maps. Screens or symbol patterns are usually Zip-a-tone or similar. Proofs are made in the Photographic Section, where equipment includes a process camera, a whirler, two photo-typesetters, a dyeline machine, and darkroom facilities.

Staff recruitment and training

Draftsmen have been recruited from other Government organizations such as the Ordnance Survey, but with the general shortage of cartographic personnel in Britain, juniors have been recruited and given an initial training of about six months at a technical college, followed by on-the-job training in the drawing office.

Many universities are now including cartography and allied subjects in their courses and it is hoped these will form the basis for a new professional cartographic career.

Promotion is usually based on experience and seniority, but consideration is given to those willing to undertake recognised courses in cartography, photogrammetry, geology, etc.

Automation

The Institute of Geological Sciences asked the Royal College of Art Experimental Cartography Unit to explore the possibility of digitizing geological information at 6" scale and producing a map by automated means. At the time of my visit to the ECU I was able to see geological detail which had been plotted at a scale of 1" to 1 mile. The linework was even, and curves were smooth and regular.

Since that time the 1-mile geological map of Abingdon has been published, and bears the note: 'The resulting data on magnetic tape were used to produce a 1" scale output in the form of geological outlines by light spot projector, and a series of masks for colour screens by heated scribing needle..... Solid geology symbols were placed by a computer typesetter. The placement of drift symbols and correction of minor errors was achieved by manual means'.

At that time the ECU was also experimenting with the production of a Geochemical Atlas, in which each map would show the occurrence of 3 elements. Maps showing sample points and symbolizing the elements and their proportion (3 gradings in parts per million) at each point had been produced (from digitized data) in 3 colours. The ultimate aim was to show areas instead of points, and to use colour tones to denote the 3 grades of occurrence of each element.

There was no suggestion that automated map production was to be introduced. The exercise was only to explore the feasibility and to compare the cost against manually drafted maps.

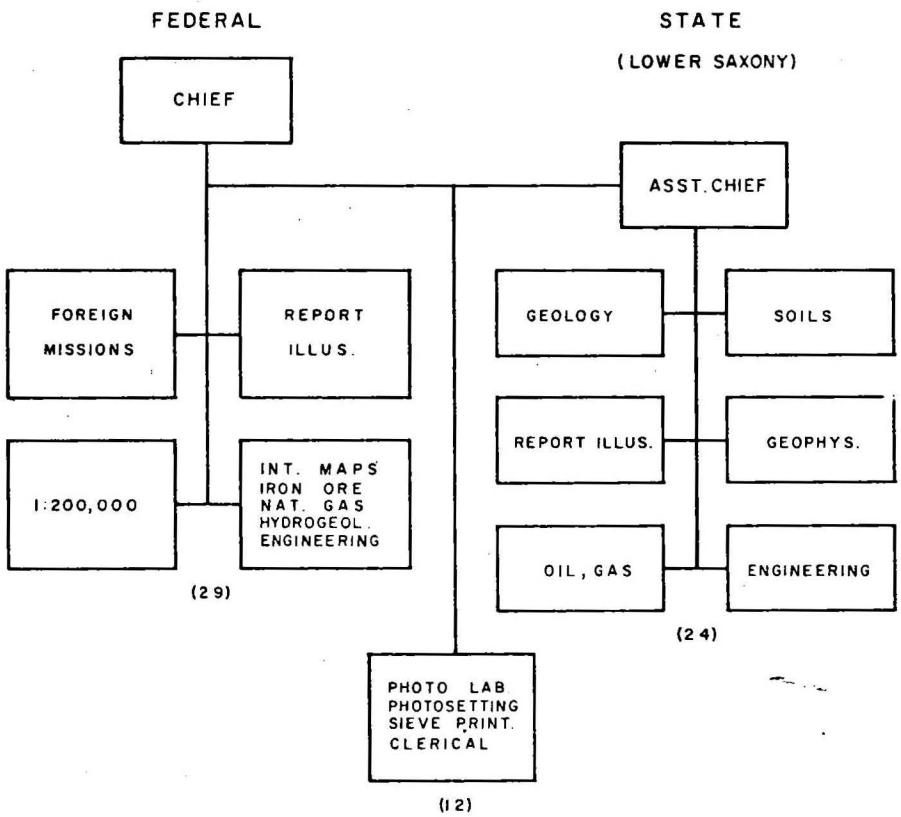

Fig.10 Cartography Section, Geological Survey of Western Germany

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GEOLOGICAL SURVEY OF WESTERN GERMANY, HANOVER: CARTOGRAPHY SECTION

This survey prepares maps for the State of Lower Saxony as well as the Federal Republic. The Cartography Section has a staff of 65 in two cartographic subsections, and a support group of photographers, printers, and clerks (Fig. 10).

Maps are prepared and published in a variety of scales from 1:5000 to 1:5 000 000. Compilation material is usually supplied at publication scale by the geologist, and preparation depends on how widely the map is to be distributed. Two methods are used for multicolour printing.

1. Maps for limited distribution, including soils and engineering maps, are printed within the survey by the 'sieve' printing method, which is a modified type of silk-screen printing. Silk screens are replaced by fine, alloy-framed PVC sieves having about 300 PVC filaments to one inch.

The component sheets of the map (one for each colour) are drawn on plastic foil, lettering is added on stripping film, and tonal screens (limited to 10%, 20%, and 50%) are applied to the various areas to receive colour. Sheets of presensitized photo-stencil film are exposed through these 'screenmasters', developed, washed, and applied to the PVC-sieve screens. These are in turn fitted to a compressed-air-operated flatbed printing machine and inked; copies are made on offset paper, similar to the silk screen process. About 500 print-downs of a two-colour map can be made each day. The system operates economically when up to 500 copies of maps averaging four or five colours are required.

Four people are employed in the printery, which operates efficiently and produces maps which are difficult to distinguish from those printed by offset lithography. Sieve printing has been successfully applied to maps requiring frequent updating or having a limited distribution. Repromat is easily amended and 500 copies of a four-colour map are reasonably cheap at about $300.

2. Copies of maps required for international distribution or in large quantity are printed by private lithographic printing firms; fair drawing using scribing and photoset lettering is usually included in the printing contract. This arrangement operates like that employed by BMR except that BMR drafting and printing contracts are let separately. The Cartography Section drafts linework to be scribed and prepares an exact mock-up of the map layout; type styles; layout and spacing of legend and other marginal detail; colour design and colour guide - all these items are incorporated. The contractor supplies proofs at the various fair-drawing stages to be checked by the cartographers. Dyeproofs of the screenmasters and machine proofs of the offset plates are also supplied and independent checks are carried out by author and cartographers.

Colour combinations are seldom used on multicolour maps. Printers claim difficulties in matching colours on adjoining sheets, consequently colour designs call for predominantly single colours.

The Report Illustration Sections

These sections prepare maps and figures (including isometric and perspective diagrams) for black and white and colour publication. Linework is drafted, and lettering is added on stripping film. Figures are frequently reproduced in screened (50%, 200 dot) black and green combinations.

Training and recruitment of staff

All geological cartographic training is carried out on the job. Difficulty has been experienced in recruiting qualified and experienced carto staff, and may be a result of the comparatively isolated area (Buchholz, an outer suburb of Hanover) where the survey is housed.

Support-group equipment

Sieve-screen printer, process camera, diazo printer and developer, two Dia-type photo-typesetters, and darkroom facilities constitute the support-group equipment.

GEOLOGICAL SURVEY OF ITALY, ROME

This was the smallest geological survey visited: it has a cartographic section of only 15. Geological cartographic training is carried out on the job; however, the preferred recruits are those who have attended an Academy of Art or similar institution.

Compilation

Geologists compile on 1:50 000 bases, which are submitted to the cartographic section and photographically reduced to 1:100 000 scale. 1:100 000 military topographic maps are used as a base, and, when recompiling, the cartographer generalizes according to the geologist's requirements. A colour guide is made and a colour design prepared; they are discussed by a panel consisting of the author and several senior cartographers.

Fair drawing and printing

Both scribing and printing are put out to contract; transparencies of the geology at 1:100 000 scale, repromat of the 100 000 military topographic map, and accurate layouts of the legend and marginal detail (except the section) are supplied to the printer, who scribes the geology and prepares a nomenclature overlay. The cross-sections are hand-drafted at 1:50 000 scale, photographically reduced to 1:100 000, and married into the geology sheet prepared by the printer. This step is necessary as scribing and mechanical symbol patterns are too inflexible to follow the detailed and complex symbolization of the rock strata. Proofs are supplied for checking by the cartographic section before plate-making.

The average 100 000 map is printed in about 30 individual colours or hues. Colour combinations are not used as 'the resultant colour is seldom predictable and is difficult to repeat or match'; however, one colour or hue may be used to overprint another. Their colour system is extremely flexible as great importance is placed on colour harmony, and colours or hues may be changed during printing to achieve the desired effect. Progressive paper proofs may be requested as each colour is printed down; some maps require as many as 50 machine proofs.

Printing costs are about four times higher than those for a similar map printed in Australia with one machine proof. Italian printers claim that they lose money printing geological maps, but still compete with each other as they recognise the prestige associated with printing maps so highly regarded in other countries.

Few text figures are produced, for publications are limited to explanatory notes.

The cartographic section does not have photomechanical facilities; all reprographic work is put out to private firms.

CONCLUSION

1. We would appear to have an advantage with our present trainee draftsman scheme which will produce efficient draftsmen in a minimum of time. However, we still lag far behind the Americans, who are able to enter the managerial grades with professional status and may become Branch heads of a cartographic establishment.

2. I feel that we offer a more complete service to the geologist than any of our overseas counterparts, and that our geological cartographer is at least being recognized as a very useful member of the geological community.

3. Australia's geographic isolation has not had such a restrictive effect on the development of cartographic skill and versatility as I had expected, and considering the youth of our lithographic printing industry, our maps create a good overall impression overseas. However, there still remain to be achieved the subtleties and points of aesthetic finesse that one finds so pleasing on the German and Italian maps.

The next decade should prove most interesting with the introduction of automation and the increased mechanized output it promises. As the last ten years has seen the penman disappear, will the next ten years see the skill of the draftsman supplanted by a programmer?