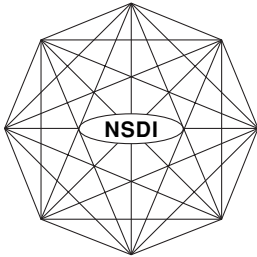


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3 **National Spatial Data Infrastructure**
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10 **Public Review Draft – Digital Cartographic Standard for**
11 **Geologic Map Symbolization**

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15 **Geologic Data Subcommittee**
16 **Federal Geographic Data Committee**
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24 **April 2000**
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35 Federal Geographic Data Committee
36 Department of Agriculture • Department of Commerce • Department of Defense • Department of Energy
37 Department of Housing and Urban Development • Department of the Interior • Department of State
38 Department of Transportation • Environmental Protection Agency
39 Federal Emergency Management Agency • Library of Congress
40 National Aeronautics and Space Administration • National Archives and Records Administration
41 Tennessee Valley Authority

42 Federal Geographic Data Committee

43
44
45 Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee
46 (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

47
48 The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy,
49 Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency;
50 the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space
51 Administration; the National Archives and Records Administration; and the Tennessee Valley Authority.
52 Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the
53 Interior chairs the committee.

54
55 FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees
56 establish and implement standards for data content, quality, and transfer; encourage the exchange of information
57 and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working
58 groups are established for issues that transcend data categories.

59
60 For more information about the committee, or to be added to the committee's newsletter mailing list, please
61 contact:

62
63 Federal Geographic Data Committee Secretariat
64 c/o U.S. Geological Survey
65 590 National Center
66 Reston, Virginia 22092

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68 Telephone: (703) 648-5514
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217 1. INTRODUCTION

218 1.1 Objective

219 This new draft standard is intended to provide to the Nation's producers and users of geologic map
220 information a single, modern standard for the digital cartographic representation of geologic features.
221 The objective in developing this national standard for geologic map symbols, colors, and patterns is to
222 aid in the production of geologic maps and related products, as well as to help provide maps and products
223 that have a consistent appearance.

224 1.2 Scope

225 This new draft standard contains descriptions, examples, cartographic specifications, and notes on usage
226 for a wide variety of symbols that may be used on typical digital geologic maps or related products such
227 as cross sections. The standard is scale-independent, meaning that the symbols are appropriate for use
228 with geologic mapping compiled or published at any scale. It is designed for use by anyone who either
229 produces or uses digital geologic map information.

230 1.3 Applicability

231 This new draft standard applies to any geologic map information published by the Federal Government,
232 whether released as hard-copy (in either offset-print or plot-on-demand format) or electronically (as
233 either Portable Document Format (PDF) files or for computer-monitor display only). Non-Federal
234 agencies and private companies that produce geologic map information are urged to adopt this standard
235 as well.

236 1.4 Related Standards

237 This new draft standard will supersede any existing U.S. Geological Survey (USGS) formal or informal
238 cartographic standards for geologic map information.

239 During preparation of this new draft standard, its relation to other standards or standards-development
240 activities was assessed, and no significant conflicts were found. For example, the International
241 Organization for Standardization (ISO) Standard 710, Parts 1-4, describes a general schema for graphical
242 display of a selected set of geologic map symbols. Although similar to some that are included in this new
243 draft standard, they were found to have limited applicability. In addition, similar standards have been
244 developed in other agencies of the Federal Government, including the U.S. Forest Service (in the geology
245 component of their Terra database) and the U.S. Army Corps of Engineers (in the geology component of
246 their Tri-Service CADD-GIS Spatial Data Standards). These were found to be somewhat specialized and
247 limited in their coverage of geologic map features. Conversely, this new draft standard provides
248 comprehensive coverage of symbology for a broad range of geologic map features.

249 1.5 Standards Development Procedures

250 This new draft standard has been developed by members of the USGS Geologic Division's Western
251 Publications Group and National Geologic Map Database (NGMDB) project. It draws heavily upon
252 previous work by USGS geologic and cartographic personnel (U.S. Geological Survey, ca. 1975, 1995a,
253 1995b), and the standards-development group gratefully acknowledges their contributions.

254 In 1995, a proposed standard was informally released by the USGS (U.S. Geological Survey, 1995a,
255 1995b). In 1996, this proposed standard was formally reviewed by geologists and cartographers in the
256 USGS, the Association of American State Geologists (AASG), which represents the state geological
257 surveys, and the Federal Geographic Data Committee's (FGDC) Geologic Data Subcommittee (GDS),
258 which is composed mostly of representatives from Federal agencies that produce or use geologic map
259 information. That review (Soller, 1996) indicated the need for some revision to the proposed standard
260 prior to its consideration by the FGDC for adoption as a Federal standard.

261 In 1996, plans were outlined to create a revised and updated Federal standard, and the standards-
262 development group was formed. A proposal to develop the revised standard was submitted by the
263 FGDC's GDS (see http://ngmdb.usgs.gov/fgdc_gds/mapsymbprop.html), and the FGDC accepted that
264 proposal in 1997. Later that year, the standards-development group produced a preliminary, beta version

265 of the draft standard, which was circulated among selected USGS and state geological survey personnel
266 for review. Comments were incorporated and, in 1999, the revised draft standard (Working Draft) was
267 submitted to the FGDC's GDS for consideration. Upon review and subsequent approval by the GDS, the
268 Working Draft was submitted to the FGDC Standards Working Group, which approved the document for
269 public review, pending adoption of minor changes. The changes were made, and this new draft standard
270 document (Public Review Draft) is now available to the public for review and comment.

271 Upon completion of the 120-day public review period, comments to the Public Review Draft will be
272 considered, and any necessary revisions will be made. The revised draft standard document then will be
273 submitted to the FGDC for formal approval as the Federal standard for geologic map symbolization.

274 After the standard is formally approved by the FGDC, the intention is that it will become a “living”
275 standard—that is, it will be maintained and revised as needed to reflect new mapping disciplines or
276 evolving usage conventions. The initial release of the FGDC-approved standard document will be
277 available in printed form and supplemented by an electronic (PDF) version. Thereafter, updates to the
278 standard document will be reflected in an online version, which will become the authoritative reference.

279 To help users maintain an up-to-date hard-copy version of the standard document, the initial release will
280 be printed in “loose-leaf” format. Subsequent updates to the standard document will be made available in
281 PDF format only, which could then be printed on a local output device and inserted where appropriate
282 into a loose-leaf binder.

283 Because this new standard is intended for use with digital applications, an electronic implementation of
284 the Public Review Draft has been prepared in PostScript format, and it is informally released as a USGS
285 Open-File Report (USGS, 1999). This PostScript implementation will enable reviewers to directly apply
286 the standard to geologic maps or illustrations prepared in desktop illustration and (or) publishing
287 software. As the formally approved standard evolves, the PostScript implementation will be updated as
288 well. Additionally, partial work on an ArcInfo (v. 7x) implementation has been completed, and this
289 implementation may also be informally released as a USGS Open-File Report in the future. Information
290 regarding updates to these and other implementation efforts will be posted on FGDC's GDS website
291 (http://ngmdb.usgs.gov/fgdc_gds).

292 The Public Review Draft document is available in both printed and PDF formats. For information on the
293 review mechanism and the deadline for submittal of review comments, as well as on how to obtain
294 copies of the Public Review Draft, please see FGDC's GDS website (http://ngmdb.usgs.gov/fgdc_gds).
295 Questions or comments may be addressed by e-mail to mapsymbol@geology.usgs.gov or, if preferred,
296 by regular mail to Map Symbol Review, c/o David R. Soller, National Geologic Map Database project,
297 U.S. Geological Survey, 908 National Center, Reston, Virginia, 20192.

298 1.6 Maintenance Authority

299 On behalf of the FGDC, the USGS will maintain the Federal standard; the responsibility for coordinating
300 Federal geologic mapping information is stipulated by Office of Management and Budget Circular A-16
301 (see <http://www.whitehouse.gov/omb/circulars/a016/a016.html>). The Geologic Mapping Act of 1992
302 (and subsequent reauthorizations) stipulates a requirement for standards development under the auspices
303 of the National Geologic Map Database (NGMDB). Under this authority, the NGMDB project will
304 function on behalf of the USGS as coordinator of this maintenance activity (see
305 <http://ngmdb.usgs.gov/info/standards/general.html>). Maintenance will be conducted in
306 cooperation primarily with the AASG, which is the USGS's partner in the Geologic Mapping Act.

307 To assist in its maintenance efforts, the NMGDB project will coordinate a standing committee that, as
308 needed, will review comments and suggestions for revisions, additions, and deletions to the standard.
309 Committee membership will be drawn from, among others, the NGMDB project, the USGS scientific
310 staff and Publications Groups, the AASG, and the academic community. This standards-maintenance
311 mechanism will be tested by forming the committee before completion of the FGDC public review
312 period, so that the committee might both help the GDS evaluate the comments received and assist in
313 preparing the final version to be submitted for formal approval by the FGDC.

314

315 2. BACKGROUND

316 2.1 Relation to Previous U.S. Geological Survey Standards

317 For many years, mapmakers within the USGS relied on a set of technical specifications given in the
318 informally named "Technical Cartographic Standards" volume (U.S. Geological Survey, ca. 1975). This
319 informal standard was available to USGS cartographers and editors as a set of green, loose-leaf
320 notebooks that allowed pages to be replaced as the standard evolved; this informal standard was
321 maintained until the mid-1980s. The technical specifications were devised to serve the needs of
322 cartographers at a time when maps were conventionally prepared for offset printing using hand-placed
323 type, hand-scribed linework, and peelcoats. This informal standard served the USGS well, but it was not
324 commonly available to other producers of geologic maps nor was it formally recognized as a standard by
325 the Nation's geoscience community.

326 Beginning roughly in the mid-1980s, digital technologies for mapmaking were both rapidly evolving and
327 becoming more widely available. The gradual adoption of digitally based mapmaking methods
328 necessitated the development of new standards that would address the requirements of the new
329 technology, both for the digital production of negatives for offset printing and for the preparation of
330 digital files for plot-on-demand or online publications. In response to the steady increase in mapmaking
331 using digital technology and the accompanying concern about the difficulties in preparing high-quality,
332 consistently produced digital maps, the U.S. Geological Survey informally released in 1995 a proposed
333 standard entitled "Cartographic and digital standard for geologic map information" (U.S. Geological
334 Survey, 1995a; see also, 1995b). As was noted above, subsequent review of that document by the USGS,
335 the AASG, and the FGDC's GDS (Soller, 1996) indicated the need for some revision prior to its
336 consideration by the FGDC for adoption as a Federal standard.

337 2.2 Changes from Previous Standards

338 In this new draft standard (contained in (normative) appendix A), descriptions, examples, cartographic
339 specifications, and notes on usage are provided for a wide variety of symbols that may be used on typical
340 digital geologic maps or related products such as cross sections. In the preparation of this standard, every
341 effort was made to retain the original symbols and their specifications from the 1995 USGS proposed
342 standard (U.S. Geological Survey, 1995a); however, many updates have been incorporated into this new
343 version. The number of symbols has increased significantly, from about 800 to almost 1200. Symbols are
344 more logically grouped; some sections have been combined with others, and a few new sections have
345 been added.

346 Many symbols, particularly lines, have been redesigned slightly so that they would more successfully
347 translate to digital applications. For instance, in the old "Technical Cartographic Standards" volume (U.S.
348 Geological Survey, ca. 1975), as well as in the 1995 USGS proposed standard (U.S. Geological Survey,
349 1995a), the lineweight for contacts was specified as .005 inches (.125 millimeters). However, experience
350 has shown that .005-inch lines do not always plot well when digitally output by high-resolution
351 imagesetters. Therefore, the minimum lineweight for contacts, as well as for most other stroked-line
352 symbol elements, has been increased to .006 inches (.15 millimeters) in this new draft standard. In
353 addition, the dash and gap lengths for many line symbols have been adjusted so that their dash-gap
354 templates can be more easily defined electronically.

355 A newly revised chart that shows a wide range of CMYK colors has been included (plate A); an offset-
356 print version of this chart has been in use at the USGS for many years, and the variety of colors has
357 proved to be sufficient for portraying complex geology shown on most maps, regardless of the output
358 medium. In addition, a chart that shows commonly used geologic patterns has been added (plate B); the
359 patterns themselves are similar to what was in the 1995 USGS proposed standard, but most have
360 undergone lineweight changes to facilitate digital output at high resolutions. The old pattern numbers
361 have been revised and the patterns are now organized into seven geologically relevant series. A few new
362 patterns have been added, and some have been eliminated. Both the color chart and the pattern chart
363 display new numbering systems that may be used with generic lookup tables in digital applications.

364 Also included in this new draft standard is a diagram showing suggested stratigraphic-age and volcanic
365 map-unit colors, and a new geologic age symbol font has been added. In addition, three new sections that

366 address map marginalia have been included: (1) a variety of bar scales, as well as calculation tables that
367 show how to convert between inches, miles, and kilometers; (2) a series of mean declination arrows,
368 showing magnetic north both east and west of true north; and (3) quadrangle location maps for each of
369 the 50 states (and District of Columbia, Guam, Puerto Rico, and U.S. Virgin Islands), as well as a map of
370 the 48 conterminous states (so that quadrangle locations covering more than one state can be shown).

371 A few new informational sections have been added to the introductory material in this draft standard. The
372 section entitled "Guidelines for Symbol Usage" provides general information about some of the symbol
373 categories in the draft standard. The section entitled "Guidelines for Color Design" provides useful
374 information on color selection and the use of patterns. The section entitled "Guidelines for Map
375 Labeling" provides recommendations on placement of text on a map.

376 In response to reviewer's comments (Soller, 1996), much of the first part of the 1995 USGS proposed
377 standard has been abandoned because it was not pertinent to this standard (for example, the sections on
378 map accuracy, geologic map content, metadata, and geocoding). In addition, no attempt has been made in
379 this new standard to provide definitions for the geologic features represented by the various symbols. For
380 such information, please refer to one of a number of reference books available; an excellent source is the
381 American Geological Institute's Glossary of Geology (Bates and Jackson, 1987, 3rd ed.; Jackson, 1997,
382 4th ed.).

383 2.3 Preparers of This Draft Standard

384 This new draft standard document was prepared by members of the USGS Geologic Division's Western
385 Publications Group for submittal to the FGDC as a Federal standard. Principal contributors to its
386 preparation (which, unless otherwise noted, consists of both the Working Draft and the Public Review
387 Draft) include the following individuals:

388 David R. Soller (USGS; Chief, National Geologic Map Database)—Coordinator, FGDC draft
389 standard development.

390 Taryn A. Lindquist (USGS; Digital Map Specialist, Western Publications Group)—Editor and
391 compiler, FGDC draft standard document; coordinator, PostScript and ArcInfo implementations;
392 designer, line symbols for PostScript and ArcInfo implementations.

393 Sara Boore (USGS; Publication Graphics Specialist, Western Publications Group)—Designer,
394 FGDC draft standard document, point and line symbols, color charts and patterns for PostScript
395 implementation.

396 F. Craig Brunstein (USGS; Geologic Map Editor, Central Publications Group)—Technical
397 reviewer, FGDC Working Draft.

398 Alessandro J. Donatich (USGS; Geologic Map Editor, Central Publications Group)—Technical
399 reviewer, FGDC Working Draft.

400 Kevin Ghequiere (USGS; Cartographer, Western Publications Group)—Designer, patterns for
401 PostScript implementation.

402 Richard D. Koch (USGS; Digital Map Specialist, Western Publications Group)—Designer, point
403 symbols for ArcInfo implementation, geologic age symbol font.

404 Diane E. Lane (USGS; Geologic Map Editor, Central Publications Group)—Technical reviewer,
405 FGDC Working Draft.

406 Susan E. Mayfield (USGS; Publication Graphics Specialist, Western Publications
407 Group)—Designer, FGDC draft standard document, color charts and patterns for PostScript
408 implementation.

409 Kathryn Nimz (USGS; Digital Map Specialist, Western Publications Group)—Designer, patterns
410 for PostScript and ArcInfo implementations.

411 Glenn Schumacher (USGS; Publication Graphics Specialist, Western Publications
412 Group)—Designer, bar scales, mean declination arrows, and quadrangle location maps.

413 Stephen L. Scott (USGS; Publication Graphics Specialist, Western Publications Group)—Designer,
414 FGDC draft standard document, point symbols and line symbols for PostScript implementation.

415 Will Stettner (USGS; Cartographer, Eastern Publications Group)—Technical reviewer, FGDC
416 Working Draft.

417 José F. Vigil (USGS; Motion Graphics Specialist, Western Publications Group)—Designer,
418 geologic age symbol font.

419 Jan L. Zigler (USGS; Geologic Map Editor, Western Publications Group)—Technical reviewer,
420 FGDC Working Draft.

421 3. TECHNICAL SPECIFICATIONS USED IN PREPARATION OF THIS STANDARD

422 The new draft standard (contained in appendix A) consists of geologic line and point symbols, geologic
423 map-unit colors and patterns, a geologic age symbol font, and related map marginalia. This section
424 provides some technical discussion regarding preparation of the draft standard and its implementations in
425 PostScript and ArcInfo formats.

426 3.1 Units for Lineweights, Lengths, and Distances

427 In this draft standard, as well as in the 1995 USGS proposed standard, the cartographic specifications for
428 lineweights, lengths, and distances are given in millimeters, in accordance with the Federal standard for
429 metrification. For ease of use, lengths have been specified in whole- or half-integer values whenever
430 possible, and lineweights and distances have been rounded to the nearest .05 mm or, in some cases, .025
431 mm.

432 The millimeter specifications were converted from those given in thousandths of an inch in previous
433 standards (for example, U.S. Geological Survey, ca. 1975). In these older versions, the thousandths-of-
434 an-inch specifications corresponded to the widths of the engraving tools used to scribe the linework. A
435 chart showing values used when converting from inches to millimeters has been included (table 1).

436 In the ArcInfo implementation of this new draft standard (in preparation), the original thousandths-of-an-
437 inch specifications were retained when designing digital versions of the symbols, because ArcInfo
438 requires lineweights and such to be specified in inches. In the PostScript implementation, however,
439 lineweights were specified in points (see table 1 for conversion values from inches to points). This is
440 because the preliminary, beta version of the draft standard document was prepared using Adobe
441 Illustrator 6.0, which required lineweights to be specified in points. Although the Public Review Draft
442 document was prepared using Adobe Illustrator 8.0, which allows lineweights to be specified in inches,
443 the lineweights were still defined electronically in points. This is mainly because Illustrator 8.0 displays
444 in its Stroke dialog box the values rounded to three significant figures; for example, a lineweight of .005
445 inches shows as 0.01 inches, and a lineweight of .004 inches shows as 0 inches. In reality, Illustrator 8.0
446 retains internally the original lineweight specifications to four or more significant figures; only the values
447 shown in the dialog box are rounded to three figures. Nevertheless, to avoid any confusion when using
448 the PostScript implementation, the lineweight specifications as originally defined in points were retained.

449 As an example of this unit-conversion process, consider the symbol for contacts (see p. A-1-1, appendix
450 A). As was stated above, the lineweight for contacts was increased to .006 inches, and this value was
451 converted to millimeters. The exact conversion of .006 inches is .152 millimeters (table 1), which was
452 rounded to .15 millimeters as the cartographic standard. However, when preparing the preliminary, beta
453 version of this draft standard document, the .15-millimeter lineweight was defined electronically in
454 Adobe Illustrator 6.0 as .432 points (table 1). Therefore, in the PostScript implementation, the lineweight
455 displayed (in the Stroke dialog box) is 0.43 points; in the ArcInfo implementation (in preparation),
456 however, the original value of .006 inches is retained as the lineweight specification for contacts.

457 Complications from unit conversion arise not just when designing line symbols but also when creating
458 point symbols and patterns, as most symbols are made of stroked lines. When creating symbols for a
459 particular application, the user should choose whichever units work best in an application and then use
460 the conversion table (table 1) to convert to those units.

461
 462
 463
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Table 1. Chart showing conversion values from inches (in) to points (pts) to millimeters (mm).

in	pts	mm	in	pts	mm	in	pts	mm	in	pts	mm
0.001	0.072	0.025	0.051	3.672	1.295	0.101	7.272	2.565	0.151	10.872	3.835
0.002	0.144	0.051	0.052	3.744	1.321	0.102	7.344	2.591	0.152	10.944	3.861
0.003	0.216	0.076	0.053	3.816	1.346	0.103	7.416	2.616	0.153	11.016	3.886
0.004	0.288	0.102	0.054	3.888	1.372	0.104	7.488	2.642	0.154	11.088	3.912
0.005	0.360	0.127	0.055	3.960	1.397	0.105	7.560	2.667	0.155	11.160	3.937
0.006	0.432	0.152	0.056	4.032	1.422	0.106	7.632	2.692	0.156	11.232	3.962
0.007	0.504	0.178	0.057	4.104	1.448	0.107	7.704	2.718	0.157	11.304	3.988
0.008	0.576	0.203	0.058	4.176	1.473	0.108	7.776	2.743	0.158	11.376	4.013
0.009	0.648	0.229	0.059	4.248	1.499	0.109	7.848	2.769	0.159	11.448	4.039
0.010	0.720	0.254	0.060	4.320	1.524	0.110	7.920	2.794	0.160	11.520	4.064
0.011	0.792	0.279	0.061	4.392	1.549	0.111	7.992	2.819	0.161	11.592	4.089
0.012	0.864	0.305	0.062	4.464	1.575	0.112	8.064	2.845	0.162	11.664	4.115
0.013	0.936	0.330	0.063	4.536	1.600	0.113	8.136	2.870	0.163	11.736	4.140
0.014	1.008	0.356	0.064	4.608	1.626	0.114	8.208	2.896	0.164	11.808	4.166
0.015	1.080	0.381	0.065	4.680	1.651	0.115	8.280	2.921	0.165	11.880	4.191
0.016	1.152	0.406	0.066	4.752	1.676	0.116	8.352	2.946	0.166	11.952	4.216
0.017	1.224	0.432	0.067	4.824	1.702	0.117	8.424	2.972	0.167	12.024	4.242
0.018	1.296	0.457	0.068	4.896	1.727	0.118	8.496	2.997	0.168	12.096	4.267
0.019	1.368	0.483	0.069	4.968	1.753	0.119	8.568	3.023	0.169	12.168	4.293
0.020	1.440	0.508	0.070	5.040	1.778	0.120	8.640	3.048	0.170	12.240	4.318
0.021	1.512	0.533	0.071	5.112	1.803	0.121	8.712	3.073	0.171	12.312	4.343
0.022	1.584	0.559	0.072	5.184	1.829	0.122	8.784	3.099	0.172	12.384	4.369
0.023	1.656	0.584	0.073	5.256	1.854	0.123	8.856	3.124	0.173	12.456	4.394
0.024	1.728	0.610	0.074	5.328	1.880	0.124	8.928	3.150	0.174	12.528	4.420
0.025	1.800	0.635	0.075	5.400	1.905	0.125	9.000	3.175	0.175	12.600	4.445
0.026	1.872	0.660	0.076	5.472	1.930	0.126	9.072	3.200	0.176	12.672	4.470
0.027	1.944	0.686	0.077	5.544	1.956	0.127	9.144	3.226	0.177	12.744	4.496
0.028	2.016	0.711	0.078	5.616	1.981	0.128	9.216	3.251	0.178	12.816	4.521
0.029	2.088	0.737	0.079	5.688	2.007	0.129	9.288	3.277	0.179	12.888	4.547
0.030	2.160	0.762	0.080	5.760	2.032	0.130	9.360	3.302	0.180	12.960	4.572
0.031	2.232	0.787	0.081	5.832	2.057	0.131	9.432	3.327	0.181	13.032	4.597
0.032	2.304	0.813	0.082	5.904	2.083	0.132	9.504	3.353	0.182	13.104	4.623
0.033	2.376	0.838	0.083	5.976	2.108	0.133	9.576	3.378	0.183	13.176	4.648
0.034	2.448	0.864	0.084	6.048	2.134	0.134	9.648	3.404	0.184	13.248	4.674
0.035	2.520	0.889	0.085	6.120	2.159	0.135	9.720	3.429	0.185	13.320	4.699
0.036	2.592	0.914	0.086	6.192	2.184	0.136	9.792	3.454	0.186	13.392	4.724
0.037	2.664	0.940	0.087	6.264	2.210	0.137	9.864	3.480	0.187	13.464	4.750
0.038	2.736	0.965	0.088	6.336	2.235	0.138	9.936	3.505	0.188	13.536	4.775
0.039	2.808	0.991	0.089	6.408	2.261	0.139	10.008	3.531	0.189	13.608	4.801
0.040	2.880	1.016	0.090	6.480	2.286	0.140	10.080	3.556	0.190	13.680	4.826
0.041	2.952	1.041	0.091	6.552	2.311	0.141	10.152	3.581	0.191	13.752	4.851
0.042	3.024	1.067	0.092	6.624	2.337	0.142	10.224	3.607	0.192	13.824	4.877
0.043	3.096	1.092	0.093	6.696	2.362	0.143	10.296	3.632	0.193	13.896	4.902
0.044	3.168	1.118	0.094	6.768	2.388	0.144	10.368	3.658	0.194	13.968	4.928
0.045	3.240	1.143	0.095	6.840	2.413	0.145	10.440	3.683	0.195	14.040	4.953
0.046	3.312	1.168	0.096	6.912	2.438	0.146	10.512	3.708	0.196	14.112	4.978
0.047	3.384	1.194	0.097	6.984	2.464	0.147	10.584	3.734	0.197	14.184	5.004
0.048	3.456	1.219	0.098	7.056	2.489	0.148	10.656	3.759	0.198	14.256	5.029
0.049	3.528	1.245	0.099	7.128	2.515	0.149	10.728	3.785	0.199	14.328	5.055
0.050	3.600	1.270	0.100	7.200	2.540	0.150	10.800	3.810	0.200	14.400	5.080

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466 3.2 Type Specifications

467 In most cases, type is specified in this new draft standard as either Helvetica (sans-serif) font or Times
468 (serif) font, two fonts that are commonly used and widely available; type sizes are given in points (see
469 table 2 for abbreviations for type faces used in this standard). Geologic age characters have been
470 specified as StratagemAge (sans-serif) font, a specialized font designed by the U.S. Geological Survey
471 (see section 38, appendix A). Other fonts besides these three may be substituted, but consider that they
472 may not be installed on all common output devices and thus may not plot correctly.

473 3.3 Color Specifications for Line and Point Symbols

474 Color has been specified as the cartographic standard for many line and point symbols in this new draft
475 standard, either because of adherence to a long-established color convention or because using color for
476 features such as folds and dikes may help them to stand out better from other full-black linework such as
477 contacts and faults. In most cases, another color or black (especially on an otherwise black and white
478 only map) may be substituted if the color specified as the standard would not be visible when printed
479 over an underlying map-unit color.

480 Whenever possible, color has been specified as either cyan or magenta, two of the four process-color
481 (CMYK, cyan/magenta/yellow/black) inks that are used both in inkjet plotters and for offset printing.
482 However, in some cases it was not practical or preferable to specify cyan or magenta as the standard; for
483 example, mineral resource assessment areas traditionally have been outlined in red (see p. A-19-1,
484 appendix A). Although it is possible to make a non-process color such as red from two or more process-
485 color inks, this should be avoided if the map is to be offset printed because of the difficulties in
486 registering large, CMYK-separated negatives. Thus, in some cases a spot color (a single-ink, non-CMYK
487 color) has been specified as the cartographic standard.

488 As a simple, general way of specifying spot colors, generic color names (for example, red and violet)
489 have been used in this new draft standard. This is mainly because in Adobe Illustrator 6.0, which was
490 used to prepare the preliminary, beta version of this draft standard, spot colors had to be chosen from a
491 list of Custom Color names. And although the final version of the draft standard was prepared using
492 Illustrator 8.0, in which Adobe changed the way spot colors are specified, the color names as originally
493 chosen in Illustrator 6.0 have been retained herein. Specifying color as these generic color names,
494 however, may not be appropriate for use with certain output media. Therefore, the user must choose a
495 method of specifying color that is appropriate for a particular output device; table 3 shows suggestions
496 for conversions of spot colors to other color models.

497 For output to an inkjet plotter, specifying a spot color as one of the generic color names is satisfactory
498 because, during the plotter's RIP¹ of the file, the color will automatically be converted to the proper
499 amounts of CMYK inks that will combine to make the CMYK equivalent of that color. For maps that are
500 to be offset printed, however, a Pantone color (single-ink spot color) should be specified (table 3).
501 Pantone colors are imaged onto separate pieces of film, thereby avoiding misregistration problems
502 caused when a color converts to CMYK and then is color separated onto as many as four pieces of film.
503 Misregistration is not a problem with single-pass inkjet-plotter output.

504 If graphical map elements are to be published as part of a web page on the World Wide Web, colors
505 should be chosen from a browser-safe, 8-bit color palette (216 colors) to avoid unwanted dithering on
506 monitors that display only 256 colors (Weinman, 1996). To aid in doing so, an attempt was made to
507 provide the browser-safe color equivalents of the spot colors given in the new draft standard (table 3).
508 These browser-safe colors are made up of the RGB (red/green/blue) values that are as close as possible to
509 the directly converted RGB-equivalent colors (table 3). However, with only six possible RGB values
510 from which to choose (000, 051, 102, 153, 204, and 255), it proved to be impossible to exactly reproduce
511 the directly converted RGB-equivalent colors. Incidentally, industry opinions on Web-safe color may be
512 changing, owing to the large number of monitors now in use that can display more than 256 colors; Chris

¹ Raster-image processing, a process that runs on all plotters, printers, and imagesetters and converts data (in either raster or vector format) to printer dots to produce an image.

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Table 2. Abbreviations used in this draft standard.

A. Color and pattern names

ABBREVIATION	MEANING	EXAMPLE OF USAGE	REF NO
B	brown	422-B (pattern)	Plate B
C	cyan	502-C (pattern)	Plate B
CMYK	cyan/magenta/yellow/black	CMYK Color Chart	Plate A
DO	dropout	204-DO (pattern)	Plate B
K	black	101-K (pattern)	Plate B
M	magenta	317-M (pattern)	Plate B
R	red	121-R (pattern)	Plate B
RGB	red/green/blue	RGB-equivalent color	Table 3
Y	yellow	CMYK Color Chart	Plate A

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B. Measurements

ABBREVIATION	MEANING	EXAMPLE OF USAGE	REF NO
cm	centimeter(s)	measurement equivalent of distance	Sec. 35
ft	foot (feet)	measurement equivalent of distance	Sec. 35
in	inch(es)	measurement equivalent of distance	Sec. 35
km	kilometer(s)	measurement equivalent of distance	Sec. 35
m	meter(s)	measurement equivalent of distance	Sec. 35
mi	mile(s)	measurement equivalent of distance	Sec. 35
mm	millimeter(s)	.15 mm (contact lineweight)	1.1.1

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C. Type styles and sizes

ABBREVIATION	MEANING	EXAMPLE OF USAGE	REF NO
H-8	Helvetica, 8 point type	GOLDEN FAULT (fault name)	2.1.8
HI-6	Helvetica Italic, 6 point type	40 (dip value)	6.3
S-8	StratagemAge, 8 point type	Tg (unit label containing geologic age character)	31.8
TBI-12	Times Bold Italic, 12 point type	<i>A-A'</i> (cross section label)	31.6

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MacGregor (*in* Dennis, 1999) recently stated that non-Web-safe colors may be acceptable to use in detailed areas, although she still recommends using Web-safe colors in large areas.

529 3.4 Color Specifications for Map-Unit Areas

530 Color is routinely added to geologic maps to help distinguish individual map units. Color can be added to
 531 map-unit polygons either as color fill, as pattern fill, or as patterns over color fill. See subsection below
 532 entitled "Guidelines for Color Design" for information on color and pattern selection.

533 To maintain control of color output, color fills for map units should always be specified using process-
 534 color (CMYK) inks, regardless of the intended output medium. If not, then the output device (be it plotter
 535 or imagesetter) will automatically convert the non-CMYK values to CMYK during the RIP, and
 536 unwanted color shifts often will take place. To aid in the selection of color fill for geologic map units, a
 537 chart showing a wide variety of CMYK colors has been included herein (plate A).

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Table 3. Spot color specifications and their equivalent colors in other color models.

[Abbreviations: CMYK, cyan/magenta/yellow/black color model (C, cyan; M, magenta; Y, yellow; K, black); RGB, red/green/blue color model (R, red; G, green; B, blue)]

Color name in draft standard ¹	Process color (CMYK) equivalent		RGB equivalent ⁴	Pantone color equivalent ⁵	Web-safe color equivalent ⁶	Example in draft standard
	Exact CMYK conversion ²	Suitable color on CMYK chart ³				
red	C 15 M 100 Y 100 K 0	C 0 M 100 Y 100 K 0	R 217 G 0 B 0	485 U	R 204 G 0 B 0 (CC0000)	Section 1.2, p. A-1-3
50% red	C 7.5 M 50 Y 7.5 K 0	C 0 M 50 Y 50 K 0	R 233 G 124 B 95	485 U (screened 50%)	R 255 G 102 B 102 (FF6666)	Section 19.5, p. A-19-6
green	C 100 M 20 Y 100 K 0	C 100 M 0 Y 100 K 0	R 0 G 109 B 44	346 U	R 0 G 102 B 51 (006633)	Section 19.5, p. A-19-6
50% green	C 50 M 10 Y 50 K 0	C 50 M 0 Y 50 K 0	R 127 G 181 B 120	346 U (screened 50%)	R 102 G 153 B 102 (669966)	Section 19.5, p. A-19-6
violet	C 45 M 90 Y 0 K 0	C 30 M 70 Y 0 K 0	R 140 G 23 B 136	Purple U	R 153 G 51 B 204 (9933CC)	Section 21, p. A-21-1
brown	C 50 M 85 Y 100 K 0	C 30 M 70 Y 70 K 0	R 127 G 30 B 2	470 U	R 102 G 51 B 0 (663300)	Section 26.1, p. A-26-1

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¹ Name of Custom Color, or spot color, as first specified in Adobe Illustrator 6.0.

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² Value after direct conversion of spot color to CMYK by Adobe Illustrator 8.0.

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³ Value of comparable color on CMYK Color Chart (plate A).

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⁴ Value after direct conversion from CMYK to RGB by Adobe Illustrator 8.0.

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⁵ Value of closest Pantone color for offset printing on uncoated paper.

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⁶ RGB value (hexadecimal value in parentheses) closest to RGB-equivalent value.

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The CMYK Color Chart was designed in Adobe Illustrator 8.0 to reproduce the offset-printed color chart entitled "Printing Colors and Screens in Use by the U.S. Geological Survey for Geologic and Hydrologic Maps" (yellow/magenta/cyan version), which has been in use for many years at the USGS. On this new version, however, the color codes were inverted so that the values now read as cyan/magenta/yellow (instead of yellow/magenta/cyan), in order to conform to the industry standard of CMYK (with K=0). Note that the color chips themselves have not changed, only the coding system has changed.

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In addition, a diagram showing suggested stratigraphic-age and volcanic map-unit colors has been included (see section 33, appendix A). This diagram was designed in Adobe Illustrator 8.0 to reproduce something similar in the old USGS Technical Cartographic Standards volume (U.S. Geological Survey, ca. 1975); in this new version, however, the range of colors was modified slightly, a few new colors were added, and the color codes were converted to cyan/magenta/yellow (from yellow/magenta/cyan).

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565 3.5 Pattern Specifications

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The old USGS Technical Cartographic Standards volume (U.S. Geological Survey, ca. 1975) contained no cartographic specifications (lineweights, dot sizes, or size and spacing of pattern elements) for its

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568 patterns. The volume dates back to a time when maps were conventionally prepared using hand-scribed
569 linework and peelcoats. In those days, patterns were preprinted onto large sheets of film, which were
570 photomechanically combined with the various peelcoats to make the CMYK negatives.

571 For this new draft standard, the patterns were recreated by scanning the old pattern sheets and then
572 tracing the pattern elements in Adobe Illustrator 8.0. In many cases, lineweights and dot sizes for the
573 black patterns were increased to facilitate digital output. A few pattern tiles were scaled to accommodate
574 the increased lineweights, and some of the lined patterns were dropped because an increased lineweight
575 would fill in the pattern, and an increase in scale would cause the pattern to be too similar to other
576 patterns in the patternset.

577 In addition to the black versions of the patterns, cyan and magenta versions of the patterns were created,
578 as well as dropout versions (yellow versions were not created because yellow patterns are not visible
579 over color fill). The lineweights and dot sizes for the color and dropout versions were increased even
580 more than for the black versions, to help them show more clearly on maps. Glacial and hydrologic
581 patterns were created only in cyan and black, as it is unlikely that magenta or other colors would be used
582 for these types of patterns. Also, if red or brown patterns were specified as the cartographic standard for a
583 particular feature, then they were added to the patternset. All patterns were renumbered and suffixes
584 indicating color were added so that all versions of the same pattern are referenced by the same number.

585 3.6 Geologic Age Symbol Font

586 A digital font named StratagemAge has been created, in which 23 special geologic age characters have
587 been substituted into positions of normal keyboard characters. These characters can be typed either
588 directly or with the Shift key; no Option, Control, or Alt keys are needed to type these characters (they
589 are all in lower-order ASCII positions that have character ID numbers below 128). This was done to
590 allow the same character positioning to work on different computer platforms without interfering with
591 special control key sequences.

592 4. GUIDELINES FOR SYMBOL USAGE

593 This section provides some guidelines regarding the use of the symbols contained in this new draft
594 standard.

595 4.1 Line Symbols

596 On a geologic map, line symbols can represent traces of either planar features such as contacts, faults, or
597 dikes, or linear features such as rivers and boundaries. The accuracy of location and (or) certainty of
598 existence of various types of lines is shown graphically by the pattern of the line symbol on the map and
599 is indicated by the following terminology used to describe symbol types:

600	Certain (solid)	Trace observed in field and accurately located
601	Approximately located (long dashed)	Trace observed in field but may not be accurately located
602	Inferred (short dashed)	Existence and location inferred from indirect evidence
603	Concealed (dotted ²)	Trace projected to surface from beneath mapped surficial
604		unit, water, or ice

605 Queries may be added to indicate local uncertainty of a trace, either within a line segment or at its end(s).
606 Queries should not be added to solid lines to indicate uncertainty of location; an "approximately located"
607 dashed line should be used instead.

608 This new draft standard does not provide quantitative definitions of the locational precision terms listed
609 above, as decisions related to the positional certainty of a line are beyond the scope of this standard. Such
610 issues should be addressed by professionals responsible for establishing mapping procedures for various
611 organizations and (or) for a particular geologic setting.

² In reality, dotted lines can be difficult to produce, and so a very-short-dashed line has long been used as the cartographic standard.

612 4.1.1 *Contacts*

613 Contacts can be used to show either abrupt or gradual changes in lithology. Annotations and (or) line
614 symbol decorations may be added to indicate where a particular feature such as dip or lineation has been
615 observed in the field.

616 Sometimes because of poor exposure or lack of accessibility, all contacts on a map can be considered as
617 "approximately located." In these cases it may be best to draw all contacts as solid, non-broken lines but
618 describe them as "approximate contact" in the explanation and (or) the database.

619 Scratch boundaries are boundaries of areas of color or pattern around which no line is drawn. For
620 example, they may define a patterned area that overprints other geologic units, such as an observed zone
621 of a particular metamorphic facies. Because, by definition, no line symbol is used, scratch boundaries
622 have been omitted from this draft standard. This does not preclude them from being used, however.

623 4.1.2 *Faults*

624 Relative offset along faults is shown by various kinds of line symbol ornamentation. Some types of
625 ornamentation are within the line symbol, such as evenly spaced sawteeth along a thrust fault. Other
626 types of ornamentation are placed along a fault to indicate the general character of that fault segment,
627 such as a "ball and bar" symbol to show normal offset. Annotations and (or) line symbol decorations may
628 be added to indicate where a particular feature such as dip or lineation has been observed in the field.

629 4.1.3 *Folds*

630 A fold structure can be represented by either the trace of its axial surface (as it intersects the ground
631 surface) or the traces of its crest (highest point) and trough (lowest point) lines. The trace of the axial
632 surface is preferred, but crest and trough lines may be substituted if specified in the map explanation and
633 (or) the database. In rare cases both may be shown if fully documented and explained.

634 Arrow symbols are added perpendicular to fold traces to indicate the different types of folds. These
635 should not be added where a particular observation has been made but, rather, should be placed roughly
636 in the center of a line segment to indicate its general character. Arrowheads may be added to a fold trace,
637 usually but not always at its end(s), to indicate direction of plunge.

638 4.2 *Point Symbols*

639 Point symbols can represent either single features that result from one observation or multiple features
640 observed at one locality. Point symbols may also be used to represent generalized areas or groups of
641 points.

642 Point symbols may be combined if necessary. If two or more types of symbol are combined, an example
643 of each type should be shown separately and described in the map explanation and (or) the database.

644 The point of observation for symbols representing planar features is located at the midpoint of the strike
645 line where it intersects the tick indicating direction of dip. If several observations are made at one
646 locality, the various point symbols are joined at their endpoints at the point of observation.

647 For linear features, the point of observation can either be in the middle of the arrow, at the end of the
648 arrow, or at the tip of the arrowhead, depending on preference. Whichever is preferred, it is important to
649 specify which method has been used in the map explanation and (or) the database.

650 4.3 *Geologic Time and Ages of Rock Units*

651 The USGS has published a scheme for the major divisions of geologic time, the age estimates of the
652 boundaries, and the symbols to be used on geologic maps (Hansen, 1991). This particular scheme was
653 adopted after a 1980 meeting of the Geologic Names Committee of the USGS (Hansen, 1991). In
654 addition, several other schemes of geologic time boundaries have been published (see, for example,
655 Harland and others, 1982; Palmer, 1983; Snelling, 1985), each of which is based on different
656 assumptions, techniques, and (or) data. Any formally published age scheme may be used for a particular
657 map, as long as the author specifies which was used.

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659 4.4 Color and Patterns

660 Many factors can influence the decision as to how to best portray the geology on a map. Separate
661 sections on color design and map labeling are included below to provide general guidelines for the
662 effective use of color and (or) patterns in map units.

663 5. GUIDELINES FOR COLOR DESIGN

664 The goal in color design is to enhance the legibility of the map, as well as to lend meaning to the data
665 presented by helping to focus attention on a particular map feature or group of features. Colors and
666 patterns should not, however, be so visually dominant as to distract from the purpose of the map. A well-
667 balanced color design can greatly improve the presentation of scientific information.

668 5.1 Factors that Influence Color Selection

669 5.1.1 *Purpose of Map*

670 Color is used differently on different types of maps. For example, on geologic maps, color is primarily
671 determined by age and type of rock, although other rules may apply for terrane maps or maps that portray
672 only one age group or type of rock. In addition, some map units, because of their geologic or economic
673 importance, may need to be emphasized.

674 Geophysical maps use several color schemes, depending on the purpose of the data being shown; usually
675 a range of colors from dark to light is used. One such scheme is a graduated set of hues of similar value
676 (for example, purple and magenta to orange and red). Another is a rainbow of hues in which the values
677 alternate between full color and lightly screened color.

678 On slope-stability maps, the brightest colors are used on areas of highest instability. Similarly, on
679 volcanic-hazard maps, areas of greatest hazard are shown in red, whereas areas of lowest hazard are
680 shown in yellow.

681 Data on hydrologic maps are frequently shown in two or three colors. On maps showing depth to water
682 table, color ranges from light blue at the shallowest depths to dark blue at the greatest depths. On maps
683 showing dissolved-solids concentrations, color ranges from dark blue where concentration is lowest to
684 dark red where concentration is highest.

685 5.1.2 *Age and Type of Rock*

686 Whenever possible, colors for ages and rock types on geologic maps should follow the scheme presented
687 in the enclosed diagram showing suggested stratigraphic-age and volcanic map-unit colors (see section
688 33, appendix A). This color scheme has been in use at the USGS for many years, and it has been adopted
689 by many geological surveys throughout the world.

690 On maps that cover a broad range of ages and rock types, relations between rocks within one age group
691 can be shown by using similar colors, whereas relations between the same type of rock in different age
692 groups can be shown by using patterns (for example, all volcanic rocks may have the same "v" pattern).
693 Patterns should be used sparingly, however, as their use can create an overly busy appearance; use them
694 only when the complexity of the map requires the diversity achieved by the use of patterns.

695 When it is not feasible to show map units in the suggested age color, such as on surficial maps, terrane
696 maps, or on maps where most units are in one age group or consist of one rock type, other characteristics
697 should be emphasized with color. On surficial maps, for example, it may be desirable to show all glacial
698 deposits in one color, landslide deposits in another, lacustrine deposits in another, and alluvial deposits in
699 yet another. On terrane maps, color may be used to show lithotectonic relations between various groups
700 of rocks.

701 On maps that are mostly one age group, it is best to distinguish sedimentary rocks from volcanic rocks
702 (usually shown in reds or other bright colors) and plutonic rocks (usually shown in pinks). On maps that
703 are mostly one type of rock, differentiation between different rock sequences can be shown through the
704 use of different colors.

705 Although it is preferable to follow the aforementioned guidelines, some rock types defy such guidelines

706 because they traditionally have been shown in a particular color. For example, serpentinite and other
707 ultramafic rocks characteristically are shown in purple; limestone usually is shown in bright blue; and
708 glacial till often is shown in light green.

709 5.1.3 *Size of Map Areas*

710 In general, small map areas should be shown in darker colors and large areas should be shown in lighter
711 colors. An exception to this may be in situations when numerous small bands of map units are shown; in
712 this case it may be best to alternate light and dark colors. In the case of units that consist of both large
713 and small areas, add labels and leaders to the smaller units to avoid confusion. See section below entitled
714 "Guidelines for Map Labeling" for recommendations on placement of unit labels and leaders.

715 Because it is more difficult to clearly distinguish color in small areas, it is very important to choose as
716 unique a color as possible for units that are present in only small areas. The minimum size of unit area
717 that can show color is about two square millimeters; anything smaller will need to be labeled. In addition,
718 exercise caution when using patterns in small areas because small areas may fail to show enough of the
719 pattern to adequately identify a unit; about one square centimeter is the minimum size to clearly show
720 patterns. If there can be any ambiguity in a unit area's identification, it is safest to add a label and leader.

721 5.1.4 *Contrast*

722 Adequate contrast enhances readability. A key factor is not so much the difference in hue, such as blue or
723 green, but the difference in intensity. Contrast should not, however, be so great as to be glaring, but it
724 should be significant enough for easy legibility. Units that need to be emphasized should be assigned
725 colors that stand out and contrast well with the colors of less important units. In addition, greater contrast
726 is required for small areas, whereas a more subtle contrast is sufficient for larger areas.

727 5.2 *Specifying Color Values*

728 Color values must be high enough to provide adequate contrast but not so great that they prevent the unit
729 labels, structure symbols, and topographic base from showing clearly. Except in small areas, magenta
730 and cyan should be used in intensities of 50% or less. A greater intensity of cyan might obscure drainage
731 features (commonly shown in cyan), and a greater intensity of magenta might obscure magenta fold axes
732 and dikes. As a general rule, use a combination of color values that, when added together, totals 100 or
733 less (for example, 30% cyan/40% magenta/20% yellow; $30+40+20 = 90$).

734 To maintain enough contrast between two colors, try to keep at least a 20% difference between one of the
735 color values (for example, 30% cyan/8% magenta/20% yellow and 50% cyan/8% magenta/20% yellow).
736 A small percentage (8% or 13%) of black can sometimes be added to create more color combinations.

737 There are a few colors that should not be used on a geologic map. Avoid using 8% yellow because it is
738 too light and cannot easily be distinguished from white. In addition, it may be wise to avoid using 13% or
739 20% cyan, as these colors may look like a body of water.

740 On maps that are to be offset printed, it may be best to use a solid (100%) single-ink color such as cyan,
741 magenta, yellow, or a particular spot color in very small areas to avoid misregistration problems. For
742 example, 100% cyan may be used to show small limestone blocks in melange, or 100% magenta may be
743 used to show thin rhyolite intrusions.

744 5.3 *Use of Patterns*

745 Patterns can be printed either in black, in color, or as a dropout. Ideally, patterns should be used sparingly
746 and only when necessary for clarification, as they can add unnecessary complexity to a map. To select
747 appropriate patterns for a map, both the type of rock and the size and (or) orientation of map-unit areas
748 must be considered.

749 Although some flexibility exists in the use of patterns, some patterns are traditionally and exclusively
750 used for certain rock types: for example, "+" patterns are used for plutonic rocks, and irregular "v"
751 patterns represent volcanic rocks. For units that are present only in small areas, a tight, random pattern
752 will fit more of the pattern elements into a particular area. Exercise caution, however, when choosing
753 metamorphic patterns that display a strong directionality, as their use may imply a general orientation of
754 metamorphic fabric that in reality is much more varied than the pattern may indicate.

755 5.3.1 *Overprint Patterns*

756 Black overprint patterns are less effective than color in most situations, as they can conceal base-map
757 information or interfere with type or structure symbols. Thus, it may be best to restrict the use of full-
758 black patterns to small, uncluttered areas; if a map-unit label is needed, it can be placed outside the area
759 and leadered in. Black patterns can be screened to reduce their intensity, but be aware that doing so may
760 lead to misregistration problems on maps being prepared for offset printing; this is because the color fill
761 underneath such screened elements will most likely be masked out during the RIP.

762 Color overprint patterns are usually printed in either cyan or magenta, but sometimes a spot color such as
763 red is used. For offset printing, it is best to use only one color for overprint patterns, as using more than
764 one color can cause misregistration problems.

765 5.3.2 *Dropout Patterns*

766 Dropout patterns cause one or more of the CMYK colors that combine to make a unit color to be
767 transparent, thus allowing the remaining color(s) to show through. Their use can be especially effective
768 on a map that has a large amount of labeling or many structure symbols.

769 For output to a single-pass inkjet plotter, a dropout pattern may be applied to all of the CMYK colors that
770 make up a unit color; the dropout pattern would then show as white. Be aware, however, that doing so
771 may cause that unit to stand out more than is desired. For offset printing, only one color should be
772 dropped out, as dropping out more than one will lead to misregistration problems; in general, the most
773 dominant (the one with the highest value) color other than yellow should be the one dropped out.

774 6. GUIDELINES FOR MAP LABELING

775 Map-unit labels are the most common labels on geologic maps. Other labels include base-map
776 information, feature names, and data items such as dip labels, gold concentrations, well depths,
777 radiometric ages, and sample locality numbers. Before the use of digital technologies for mapmaking,
778 labels and leaders were placed by either hand-drawing them or applying stick-up type. Nowadays, using
779 digital mapmaking techniques, labels can be automatically plotted from information in a database;
780 however, this often results in labels overprinting other map features, requiring them to be interactively
781 repositioned or deleted. Regardless of the method employed, effective label placement is an important
782 factor in producing a useful map.

783 For a map to be easily read, labels and leaders should be placed where they are clear and legible, with
784 care taken to avoid overprinting of other labels or map features. They should not create an overly "busy"
785 or cluttered appearance, which makes recognition of map patterns and shapes and map-element
786 distribution difficult to discern. Enough features should be labeled so that the reader can identify all of
787 the various map elements; no unlabeled map feature should leave the reader guessing.

788 Labels and leaders should be carefully placed to avoid overprinting of linework, symbols, or other labels.
789 They should not obscure other map elements or make them difficult to read, nor should they obscure
790 base-map features that are mentioned in the text or that are useful in locating places on the map.

791 6.1 Strategies for Map Labeling

792 Commonly, color or pattern can be used to identify an unlabeled polygon if a nearby polygon of the same
793 unit is labeled. Therefore, color selection can be critical when deciding whether or not to label a
794 particular polygon. Thus, it is important to complete the color and pattern design of the map before
795 attempting to place and move unit labels, especially for complex maps or those that have many units.

796 There are no precise rules for which and how many of the polygons on a map should be labeled, but the
797 following are some general guidelines. If a unit has a unique and clearly distinguishable color or pattern,
798 it is not necessary to label every polygon of that unit. Color and pattern can carry the identification of a
799 group of polygons of the same unit as long as some of them are labeled. Use judgment when deciding
800 whether the color for that unit is distinctive enough and (or) whether a particular unlabeled polygon can
801 be visually or logically associated with any nearby labeled polygons of the same unit. In small polygons,
802 however, even the most distinctive color or pattern may be difficult to discern. If there might be any
803 doubt, add a label and leader.

804 At least one polygon of every unit within a "normal field of view" should be labeled. This field of view is
805 the area in focus when the map is viewed at a comfortable, readable distance. In uncluttered areas of the
806 map or in areas of relatively simple geology, this field of view might have a radius of about two inches;
807 in geologically complex or cluttered areas, it may be much smaller. The reader should not need to search
808 across the map trying to find a labeled polygon that has a color that matches an unlabeled polygon.

809 In addition, maps that are to be downloaded from the Web will be sent to a plotter of unknown type, and
810 there is no guarantee that colors that appear distinct when plotted on your plotter will also be
811 distinguishable when plotted on other plotters. The more polygons that are labeled, the less chance of
812 ambiguity and confusion.

813 6.2 Font Selection

814 When placing labels digitally, it is important to use the same font that will be used for final publication.
815 The size and kerning (spacing of letters) of characters are different for different fonts, even those having
816 the same point size. If labels have been carefully placed in tight areas using one font, but then another
817 font is used for final publication, the labels may overprint other features because the new font may have
818 longer character heights and string lengths. In addition, it is important to always use PostScript fonts,
819 which are needed to ensure consistent final output for both print and digital publications.

820 In most cases, Helvetica, Times, or StratagemAge should be used. Other fonts besides these three may be
821 used, but they may not plot correctly on all common output devices. The important thing to remember is
822 to use the correct kind of font: use a sans-serif font like Helvetica or StratagemAge for most type on a
823 map, such as unit labels, dip values, and fault names; use a serif font like Times for labels on cross
824 sections. For base-map information, use a combination of serif and sans-serif fonts; the general rule is to
825 follow the styles found on a published topographic map sheet.

826 6.3 Type Size and Style

827 The ideal size for map-unit labels is 8 pt, although labels as small as 6 pt may be substituted where space
828 is tight. Fractional font sizes may be used if needed, and different sizes can be mixed on the same map. If
829 unit labels contain subscripts or superscripts, the minimum unit-label size should be 7 pt; then the size for
830 the subscript or superscript character would be 5 pt, two point sizes smaller than normal.

831 Other sizes and styles are used to label different features. In general, use 8 pt type for names of faults and
832 major structures, for sample locality numbers and radiometric ages, and for fault (U/D, A/T) and contact
833 (Y/O) ornamentation. Use 6 pt italic type for dip or plunge values. Use 11 pt italic type for cross-section
834 labels. For labels of larger features, type size and (or) kerning (letter spacing) may be increased to
835 improve legibility.

836 6.4 Label Placement

837 Labels for linear map features should be aligned along those features. Other labels should have a logical
838 or comfortable orientation relative to the map. In rare cases it might be desirable to have labels run
839 parallel to lines of latitude, but in general they should be oriented horizontally.

840 Unit labels and dip values should always be oriented horizontally. They should not overprint other map
841 elements such as linework, point symbols, or any other dip values and labels, nor should they obscure
842 base-map features that are referenced in text or are needed to orient the map in the field. Single labels can
843 be used to identify more than one polygon; use multiple leaders where necessary.

844 Unit labels should not be placed in dark-colored units or in densely patterned areas, both of which would
845 make the labels hard to read; instead, move labels outside such areas and add leaders. If a label must be
846 placed in a dark-colored or densely patterned unit, it may be necessary to mask out the color or pattern
847 around the label to help make it more legible.

848 6.5 Leader Placement

849 Leaders should be drawn as straight lines, not bent or curved. They should not stop at or outside polygon
850 boundaries but should extend into unit areas. Leaders should cross polygon boundaries at as high an
851 angle as possible; they should not cross through other units to reach a particular unit unless absolutely
852 necessary. Multiple leaders emanating from a single label should not be joined at their "label" ends.

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