Methods to create ArcMap® styles with examples for lithology and time

By Lorre A. Moyer, Jordan T. Hastings, and Gary L. Raines

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Abstract

ArcMap® style files (.style extension) can be used to standardize map symbolization. This report describes the methods used to create several styles for lithology or geologic time. The styles are color fills which were created by assigning RGB color values to attributes of polygon shapefiles. The terms symbolized were either generated from terminology hierarchies from various sources or digitized from scanned images of existing legends. For large lithology lists, a table format was used as a convenient method for experimenting with shades of color as well as for documenting the RGB color values. Examples of styles were adapted or created from the following legends: the International Stratigraphic Chart (ISC) and the USGS Color Code version of the ISC; the Decade of North American Geology (DNAG-1983 Geologic Time Scale); the North American Geologic Map Data Model version 4.3 (specifically lithclass 4.3 and its successors lithclass 6.1 and lithclass 6.2); and the State Geologic Map Compilation (SGMC). The digital package consists of ArcMap® styles, and Microsoft® Excel color documentation tables. The software used includes Environmental Systems Research Institute (ESRI®) ArcGIS® version 9 (ArcMap® module) and Microsoft® Excel 2003. Other software tools used in preparing the files were Pixie color-picker, and the Science Language Interface Module.

Introduction

It is desirable to have standardized styles available for lithology and geologic time for mineral resource and other geologic uses, especially for suites of maps. Selecting color fills for large lithologies consisting of hundreds of units while maintaining a visual distinction in the traditionally accepted color ranges is a time-consuming process. The ESRI® ArcMap® style files (.style extension) released with this report offer examples of ready-made color fills that can improve map communication by presenting a uniform appearance. Fills are identified by textual names which appear as attributes of the polygons being symbolized. The report describes a spreadsheet method that was used for selecting color fills as well as for documentation of RGB (red, green, blue) color codes. The digital files are available online at *http://pubs.usgs.gov/of/2005/1314/*.

Background information on existing lithology color schemes can be found in Compton (1962), the American Association of Petroleum Geologists Correlation Chart Series (1983), and the Pacific Northwest lithology map by Johnson and Raines (2001). Examples of terminology schemes can be found in Compton (1962), Streckeisen (1973a, 1973b), Folk (1974), Pettijohn (1975), Gilliespie and Styles (1999), Roberson (1999), and Hallsworth and Knox (1999).

Because currently no U.S. Geological Survey color standard exists for lithology, and only color guides for geologic time, selected geologic map color schemes can often be diverse. Traditionally various shades of yellow are commonly used for unconsolidated material, pinks for granitic rocks, purples for ultramafic rocks, blues for carbonate-rich sedimentary rocks, dark-yellows to light-orange for sandstones, and greys for shales. However, attempting to assign unique color values to large lithologies, while adhering to accepted color ranges, remains a challenge. On occasion it is necessary to use color shades outside the range of accepted colors, or repeat them with an overlay pattern to make them distinct. Other considerations include how specific lithologies appear on a map. Lithologies that often occur adjacent to each other are easier to discern when contrasting colors are used. Ink can be conserved when printing paper maps by using lighter shades for the most frequently occurring lithologies.

Versions of several ESRI ArcMap® style files for lithology and geologic time were created from terminology schemes used for specific projects, or scanned and digitally recreated from existing legends. Shapefiles were used to encode box diagrams representing legends, often hierarchically arranged, to which color fill styles were applied. Methods for creating styles were demonstrated using the following legends: the International Stratigraphic Chart (ISC) at *http://www.stratigraphy.org/cheu.pdf* and the USGS Color Code version of the (ISC_USGS) at *http://www.stratigraphy.org/codus.pdf* ; the Decade of North American Geology (DNAG-1983 Geologic Time Scale) at *http://www.ucmp.berkeley.edu/fosrec/TimeScalebig.jpg*; the North American Geologic Map Data Model (specifically lithclass 4.3 at *http://nadm-geo.org/dmdt/Model43a.pdf* and its successors lithclass 6.1at *http://nadm-geo.org/dmdt/pdf/lithclass61.pdf* and lithclass 6.2, which is not yet posted at *http://nadm-geo.org/* ; and the currently in progress USGS Surveys and Analysis State Geologic Map Compilation (SGMC) project. Microsoft® Excel tables were used to document RGB color values and provide a convenient method for color experimentation.

The style files released with this report were created using the Environmental Systems Research Institute (ESRI®) ArcGIS® version 9 (ArcMap® module) software. The color documentation tables were created with Microsoft® Excel 2003 software. Tools used in preparation of these files but not included with this report are: “Pixie”, a freeware color-picker utility (available online from *http://www.nattyware.com*); and the Science Language Interface Module “SLIM” (Hastings, 2003).

Acknowledgements

The authors appreciate the assistance of several U.S. Geological Survey staff in preparing this report. In particular, Doug Causey, Bruce Johnson, Steve Ludington, and Michael Zientek provided input on terminology, tools, and style design. Comments and suggestions made by the reviewers, Doug Causey and Barry Moring were also much appreciated.

Overview of digital files

The digital files provided include ArcMap® style files and Microsoft® Excel tables that document the color codes for the lithology or geologic time versions listed and briefly described in

table 1. View the style file color fills in ArcMap® using the Style Manager. Each style contains a set of color fills with associated attributes used to assign the fills in ArcMap® to polygon features by matching the attribute terminology.

Table 1. List of digital files provided in this publication

File Name	File Description
	Digital Files
lith4_3.style	ArcMap® style for North American Geologic Map Data Model (NADM) Lithology Class version 4.3
lith6_1. style	ArcMap® style for North American Geologic Map Data Model (NADM) Lithology Class version 6.1
lith6_2.style	ArcMap® style for North American Geologic Map Data Model (NADM) Lithology Class version 6.2
SGMC.style	ArcMap® style for the State Geologic Map Compilation (SGMC) draft version SGMC lithology, 2005
DNAG.style	ArcMap® style for Decade of North American Geology (DNAG - 1983 Geologic Time Scale)
ISC.style	ArcMap® style for International Stratigraphic Chart (ISC), 2004
ISC_USGS.style	ArcMap® style for International Stratigraphic Chart (ISC) version USGS Color Code, 2005
Time_Compiled.xls	Excel workbook for geologic time includes worksheets for the Table for Decade of North American Geology (DNAG) 1983 Geologic Time Scale, the International Stratigraphic Chart (ICS) and the USGS Color Code version of the ISC.
Lith_Compiled.xls	Excel workbook for lithology includes worksheets for North American Geologic Map Data Model (NADM) Lithology Class versions 43, 6.1, 6.2, and a draft version of the State Geologic Map Compilation (SGMC).

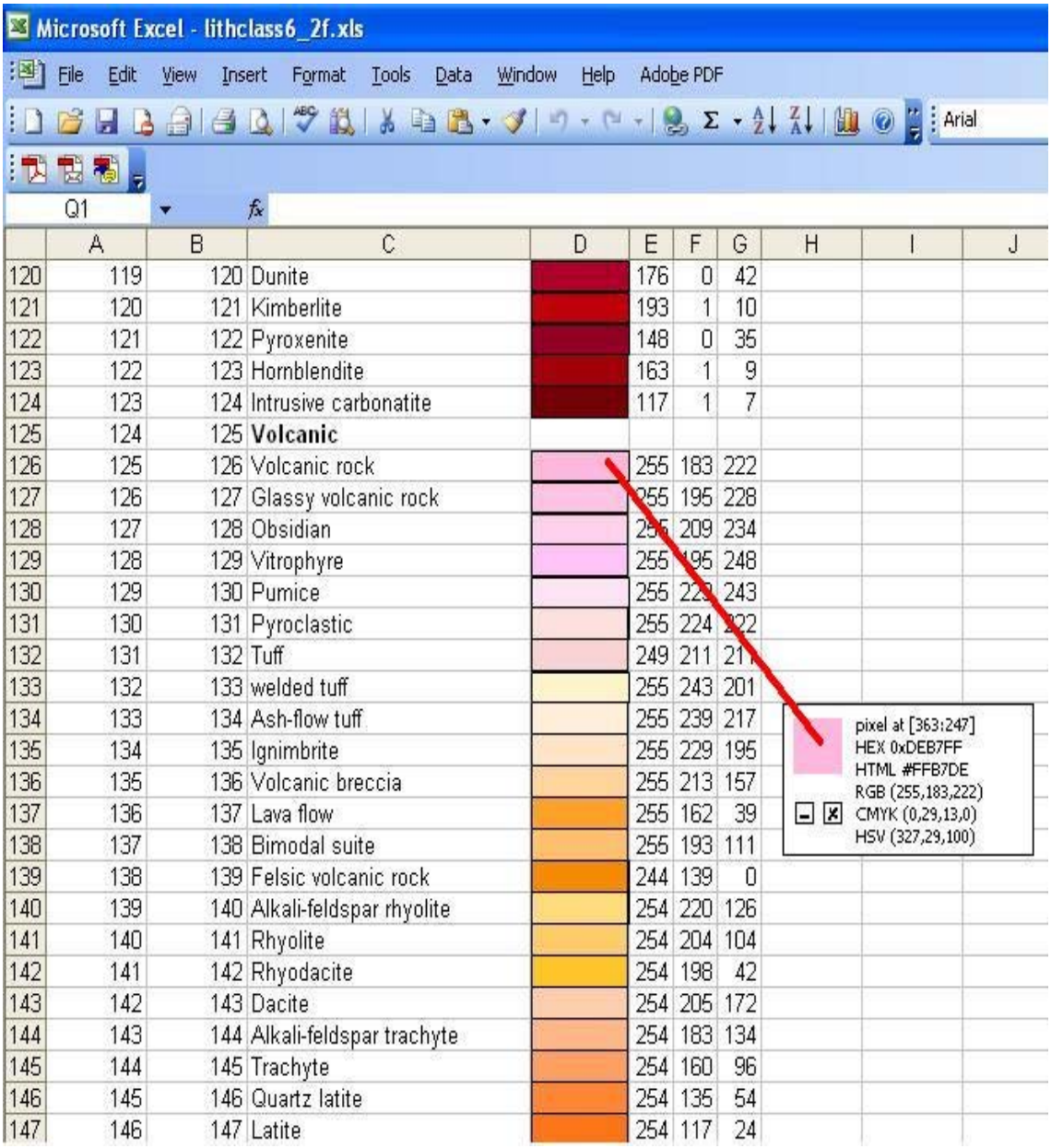
Color Discussion

It is important to be aware that sources for error in color display include the settings specific to scanner hardware and software, the quality of the original scanned material, and the monitor color calibration. RGB color codes were used for optimal on-screen viewing in ArcMap®, but are not normally used for printed products that may vary widely from the color shades displayed on screen. The geologic time scales for the ICS and the USGS Color Code version of the ICS have established colors. The DNAG chart is in black and white and custom colors were assigned to the terminology. Lithology style fills were selected by the USGS project leaders for the specific project needs. Color selection was facilitated by the use of a documentation table for the RGB code and color fill. Note that when creating a color fill box in an Excel table, the box must be smaller than the table cell size in order to properly sort with the terminology. The following examples are meant to show how to create or adapt ArcMap® color fill styles and tailor them for spatial data purposes such as a suite of digital maps.

Methods to create style sheets

Geologic time

Paper legends for geologic time (ISC, ISC-USGS Color Code, and DNAG-1983) were scanned and digitized in ArcMap® into polygon shapefiles and terminology was added to the attribute tables. The ISC-USGS Color Code at *http://www.stratigraphy.org/codus.pdf* provided the RBG values that were used with the attribute terminology to create the USGS Color Code ArcMap® style. "Pixie" freeware was used to determine the on-screen RGB values of the colors for the ICS chart at *http://www.stratigraphy.org/cheu.pdf* , or to verify that the correct color values were assigned to fills in the style file and the documentation table (fig. 1). These values are subject to the possible color errors discussed above. Custom color fill assignments were made to the black and white DNAG time scale at *http://www.ucmp.berkeley.edu/fosrec/TimeScalebig.jpg*. The geologic time RGB color codes and color fills were documented in the Microsoft® Excel table, *Time_Compiled.xls.* There are worksheets for each time scale and a compilation of terminology and color fills for all three with synonyms or name variations placed in parenthesis.

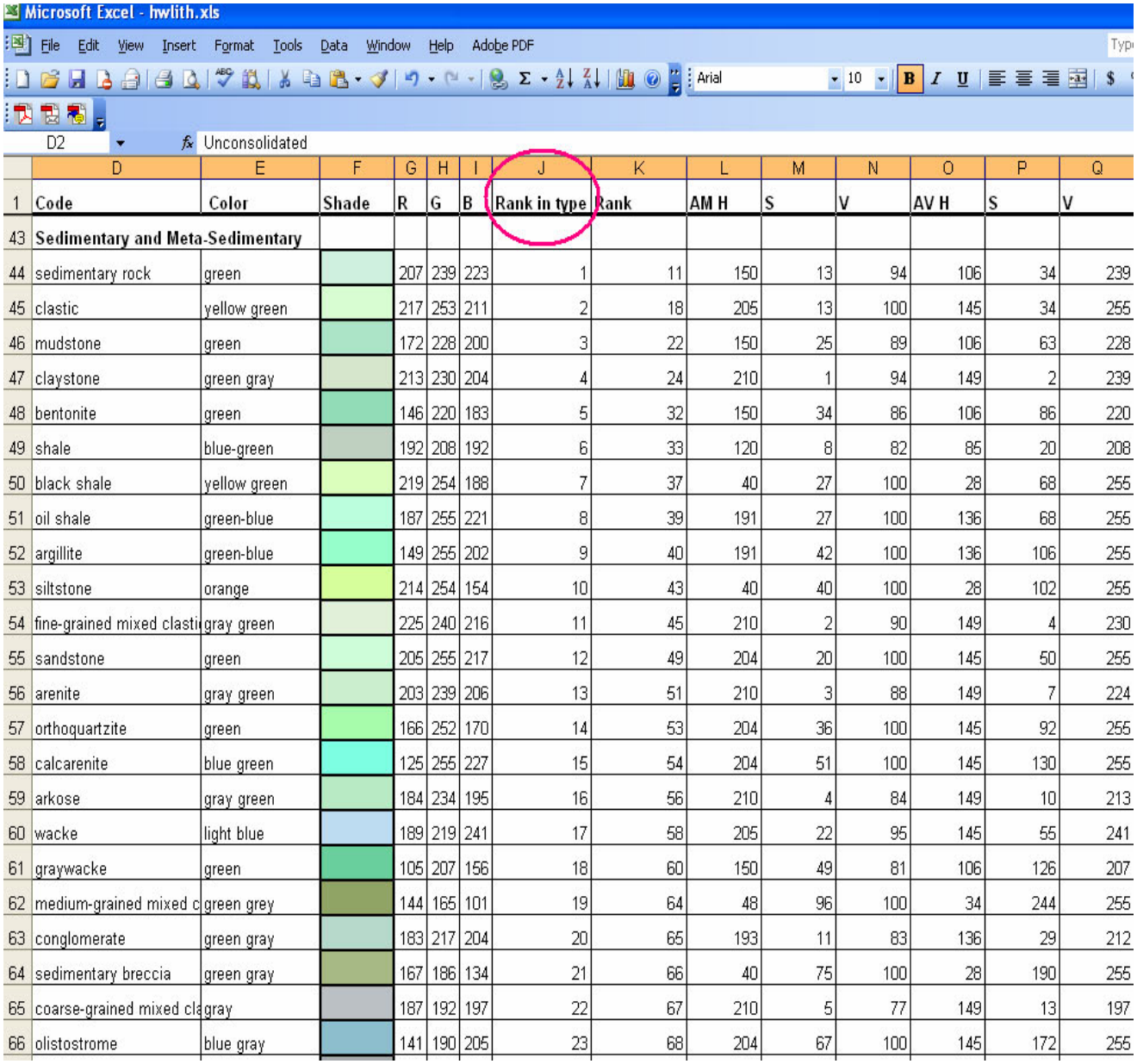


	A	B	C	D	E	F	G	H	I	J
120	119	120	Dunite		176	0	42			
121	120	121	Kimberlite		193	1	10			
122	121	122	Pyroxenite		148	0	35			
123	122	123	Hornblendite		163	1	9			
124	123	124	Intrusive carbonatite		117	1	7			
125	124	125	**Volcanic**							
126	125	126	Volcanic rock		255	183	222			
127	126	127	Glassy volcanic rock		255	195	228			
128	127	128	Obsidian		255	209	234			
129	128	129	Vitrophyre		255	195	248			
130	129	130	Pumice		255	229	243			
131	130	131	Pyroclastic		255	224	222			
132	131	132	Tuff		249	211	211			
133	132	133	welded tuff		255	243	201			
134	133	134	Ash-flow tuff		255	239	217			
135	134	135	Ignimbrite		255	229	195			
136	135	136	Volcanic breccia		255	213	157			
137	136	137	Lava flow		255	162	39			
138	137	138	Bimodal suite		255	193	111			
139	138	139	Felsic volcanic rock		244	139	0			
140	139	140	Alkali-feldspar rhyolite		254	220	126			
141	140	141	Rhyolite		254	204	104			
142	141	142	Rhyodacite		254	198	42			
143	142	143	Dacite		254	205	172			
144	143	144	Alkali-feldspar trachyte		254	183	134			
145	144	145	Trachyte		254	160	96			
146	145	146	Quartz latite		254	135	54			
147	146	147	Latite		254	117	24			

Figure 1. Example output of "Pixie" freeware, verifying color values in a documentation table.

Lithology

When only terminology was available, such as the hierarchical Lithclass 4.3, Lithclass 6.1, Lithclass 6.2 and SGMC, polygon shapefiles were generated using SLIM (Hastings, 2003). The shapefiles (hierarchical boxes) with correct lithology attributes were assigned desired color fills that were exported to a style. RGB color code assignments for the lithologies were documented using an Excel table and the color fill tool. The table format provided a convenient method for color value documentation and ranking, for example, by frequency of occurrence or position in the lithology hierarchy. Sorting the table by ranks was a technique used to experiment with shades of color according to the frequency of occurrence on a map, the position in the lithology hierarchy, rock type, or other criteria (fig. 2). The "hide" column feature of the table was used to compare side-by-side multiple versions of color shade selections (fig. 3). When satisfied with color shades in the table format, the RGB codes were entered or changed to redefine a color fill in the style file created from the generated shapefile. Using the ArcMap® style Manager, the RGB color codes were manually assigned using the "Symbol Property Editor" color selector to the correct lithologic terminology. "Pixie" was used to verify that the color code in the color documentation table and the color code entered into the style file were the same. The tables for the individual and well as the compiled lithologies are in the *Lith_Compiled.xls* . The compiled worksheet places variations on the lithologic name in parenthesis. The individual worksheets can be sorted alphabetically, by RGB codes or by the hierarchical "Id" column. In some instances the original terminology was adapted for particular style needs, for example a subset of Lithclass 4.3 terminology was used in this demonstration.



Microsoft Excel - hwlith.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

Arial 10

D2 Unconsolidated

	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Code	Color	Shade	R	G	B	Rank in type	Rank	AM H	S	V	AV H	S	V
43	Sedimentary and Meta-Sedimentary													
44	sedimentary rock	green		207	239	223	1	11	150	13	94	106	34	239
45	clastic	yellow green		217	253	211	2	18	205	13	100	145	34	255
46	mudstone	green		172	228	200	3	22	150	25	89	106	63	228
47	claystone	green gray		213	230	204	4	24	210	1	94	149	2	239
48	bentonite	green		146	220	183	5	32	150	34	86	106	86	220
49	shale	blue-green		192	208	192	6	33	120	8	82	85	20	208
50	black shale	yellow green		219	254	188	7	37	40	27	100	28	68	255
51	oil shale	green-blue		187	255	221	8	39	191	27	100	136	68	255
52	argillite	green-blue		149	255	202	9	40	191	42	100	136	106	255
53	siltstone	orange		214	254	154	10	43	40	40	100	28	102	255
54	fine-grained mixed clasti	gray green		225	240	216	11	45	210	2	90	149	4	230
55	sandstone	green		205	255	217	12	49	204	20	100	145	50	255
56	arenite	gray green		203	239	206	13	51	210	3	88	149	7	224
57	orthoquartzite	green		166	252	170	14	53	204	36	100	145	92	255
58	calcarenite	blue green		125	255	227	15	54	204	51	100	145	130	255
59	arkose	gray green		184	234	195	16	56	210	4	84	149	10	213
60	wacke	light blue		189	219	241	17	58	205	22	95	145	55	241
61	graywacke	green		105	207	156	18	60	150	49	81	106	126	207
62	medium-grained mixed c	green grey		144	165	101	19	64	48	96	100	34	244	255
63	conglomerate	green gray		183	217	204	20	65	193	11	83	136	29	212
64	sedimentary breccia	green gray		167	186	134	21	66	40	75	100	28	190	255
65	coarse-grained mixed cla	gray		187	192	197	22	67	210	5	77	149	13	197
66	olistostrome	blue gray		141	190	205	23	68	204	67	100	145	172	255

Figure 2. The table shows documentation of RBG color codes sorted by a rank in type (rock type) for facilitating color selection.

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	B	C	D	E	F	G	H	I	J	K	L
1	Hier_ID		Code	Brewer3H	R	G	B	Brewer2R	R	G	B
95			Plutonic and Meta-Plutonic								
96	1.1.2.2	1013	granite		255	239	243		255	239	243
97	1.1.2.3	1017	granodiorite		255	217	191		255	217	191
98	1.1.2	1010	granitic-rock or granitoid		255	225	232		255	225	232
99	1.1.2.4	1019	tonalite		255	122	31		255	122	31
100	6.1.2	3013	meta-granitic rock or granitoid		255	209	220		255	209	220
101	3.14	1985	porphyry		255	129	159		255	198	159
102	1.1.4.4	1045	quartz diorite/quartz gabbro/quartz anorthosite		220	255	149		233	255	249
103	6.1.2.3	3020	meta-granodiorite		242	180	150		255	180	129
104	1.1.3.7	1034	quartz monzonite		219	183	255		244	233	255
105	1.1.4.5	1046	diorite/gabbro/anorthosite		220	255	149		209	255	243
106	6.1.4.4	3048	meta-quartz diorite/quartz gabbro/quartz anorthosite		72	255	207		171	255	233
107	5	3000	metamorphosed igneous rock		255	195	209		255	195	209
108	3.13	1980	latitic-trachytic (alkaline) volcanic suite		255	129	159		200	145	255
109	3.9	1960	andesitoid-rhyolitoid (calc-alkalic) volcanic suite		255	111	145		183	255	39
110	6.1	3002	metamorphosed plutonic QAPF rocks		255	179	197		255	179	197
111	3.8	1955	dioritoid-granitoid (calc-alkaline) plutonic suite		255	111	145		245	255	225
112	1.1.2.2.3	1016	monzogranite		245	162	122		231	255	183
113	1.1	1001	plutonic QAPF rocks		255	167	188		255	167	188
114	1.1.3	1025	syenitic-rock or syentoid		190	125	255		190	125	255
115	1.1.1.2	1007	quartz-rich granitoid or quartz-rich-granitic-rock		255	39	90		255	39	90
116	1.1.4.1	1041	quartz monzodiorite/quartz monzogabbro		233	255	249		129	255	222
117	6.1.4.5	3049	meta-diorite/gabbro/anorthosite		73	255	207		73	255	207
118	3.7	1950	lamprophyres		255	111	145		0	248	183

Figure 3. Example of using tables a side-by-side comparison of different color fills versions.

Description and use of style files

In ArcMap®, styles are applied to features using the "Match to symbols in a style" choice under the "Categories" menu in Symbology tab (fig. 4). In order to be successfully applied, the lithologic terms used in the feature attribute table must precisely match the terms used in the style (fig. 5). For example, the terms must be spelled and capitalized exactly in the same manner or the style will not be applied properly (fig. 6). It is important to note the variation and peculiarities of terminology naming formats used in the style examples presented in this report. The style subset for Lithology Class version 4.3 capitalizes the first letter of each term and uses a dash in the term "Quartz-feldspar Schist." The Lithology Class version 6.1 style uses all lower case with occasional use of dashes and parenthesis for example, "meta-basalt" and "volcanic rock (aphanitic)." The Lithology Class version 6.2 style capitalizes the first letter of each term with occasional dashes or slashes such as, "Meta-argillite" and "Sub/supra-glacial sediment." The State Geologic Map Compilation (SGMC) style capitalizes the first letter of the first term, occasionally capitalizes the second term, and uses underscoring, for example, "Sandstone_Mudstone." Any of these styles can be altered or adapted by changing the color fill or naming format in the ArcMap® Style Manager, or used as a starting point in developing customized ArcMap® styles.

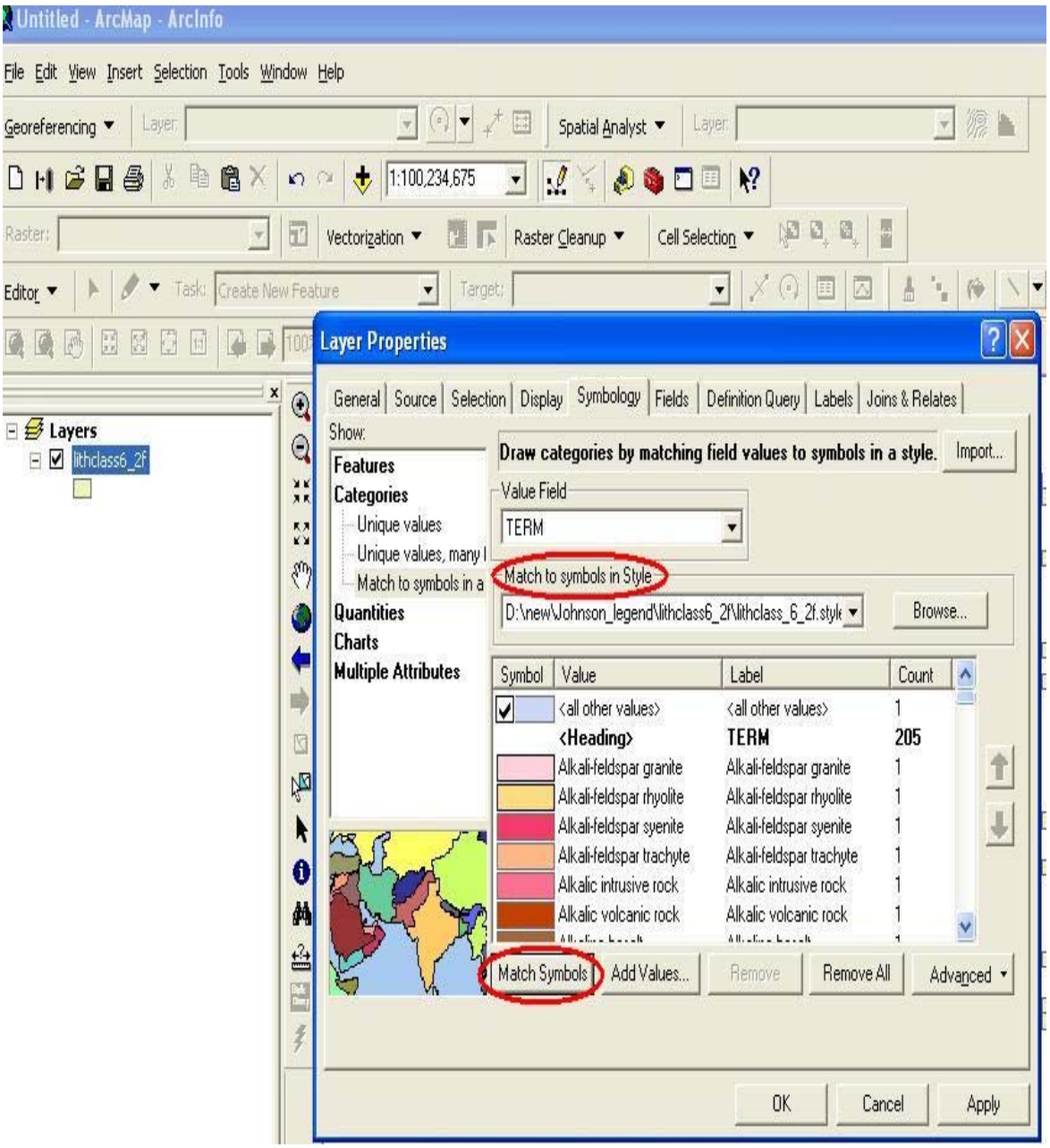

Figure 4. Match symbols in the style to the attribute value field.

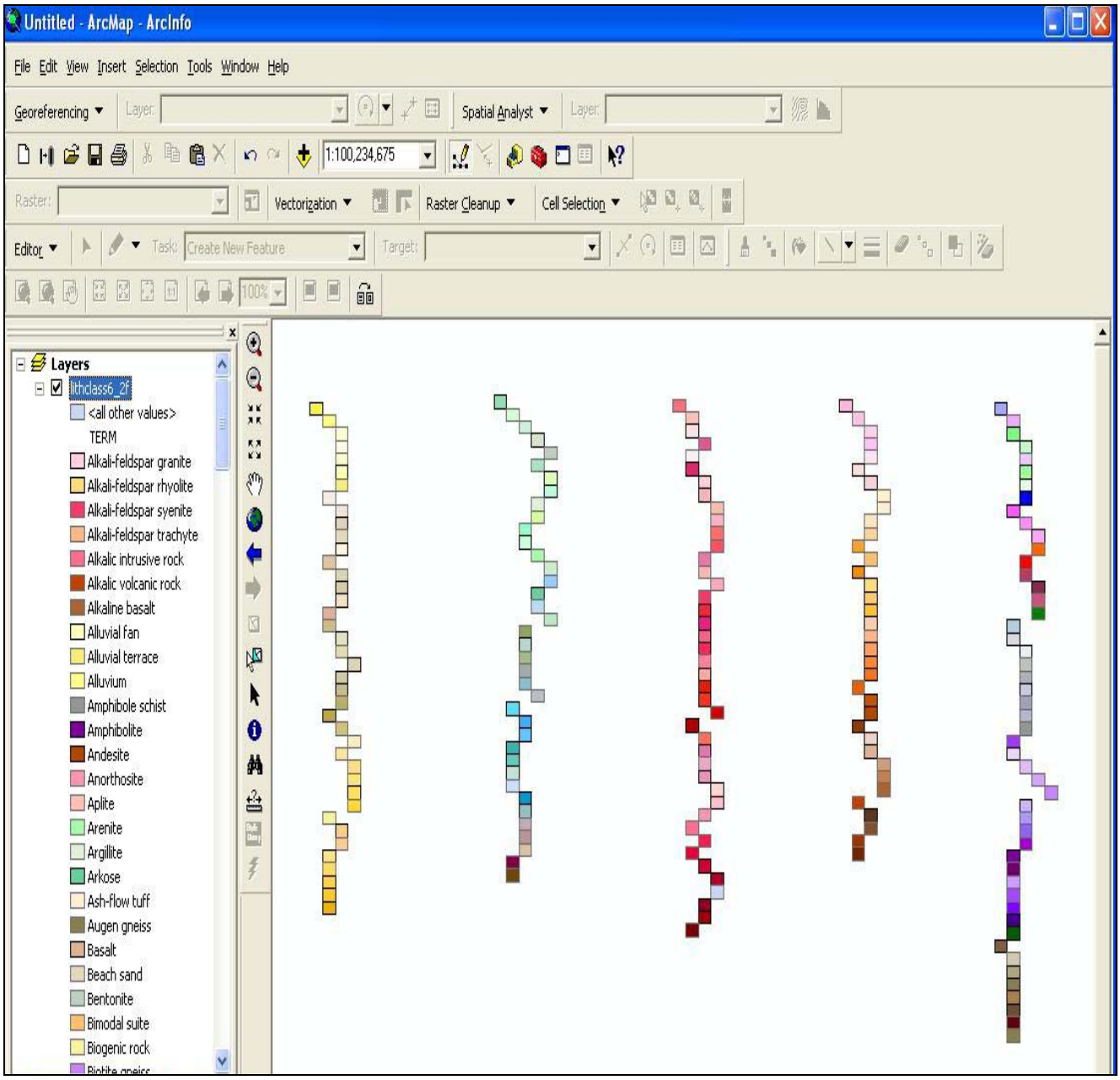

Figure 5. Example of styles successfully applied to the polygon shapefile generated from hierarchical terminology.

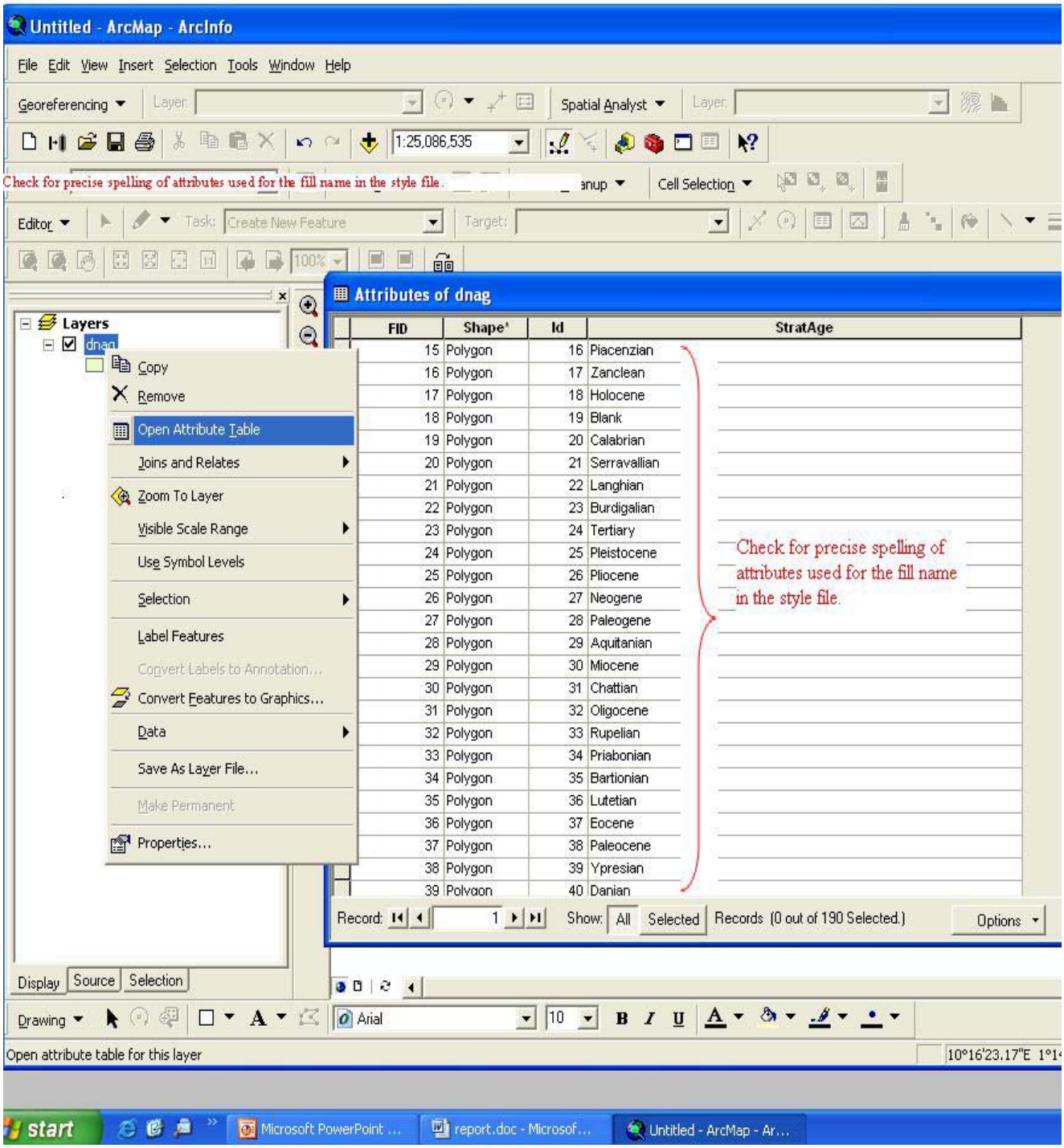

Figure 6. Attribute terminology must match exactly with fill name in the style file.

Styles can be viewed in the ArcMap® Style Manager or printed using the Style Dump application provided in the ArcGIS® Developer Kit samples located in Program Files>ArcGIS>Developerkit>samples>Cartography>Styles>Style_Dump. The ready-made styles can be directly applied to a correctly attributed feature layer in ArcMap®. The styles also can be customized by making changes to fill colors or names in the Style Manager or by changing color fills using the feature Symbology tab. Any changes can be incorporated into a new style by selecting "Export map style" under the Tools>Styles menu in ArcMap®. Symbology saved in a layer file (.lyr) can be exported as a style at a later time. ArcGIS® styles files are normally stored in Program Files>ArcGIS>Styles, however, they can be saved in any custom path.

The following links are to the geologic time and lithology documentation tables: *Time_Compiled.xls* and *Lith_Compiled.xls*. The column headings **R**, **G**, **B**, represent the RGB color codes. *Time_Compiled.xls* has a worksheet for International Stratigraphic Code, the USGS Color code, and the Decade of North American Geology represented by the abbreviations **ISC**, **ISC_USGS**, and **DNAG** respectively. The **Compiled_Time** worksheet integrates the terminology and displays the color codes from all three worksheets, placing synonyms and naming variations within parenthesis. *Lith_Compiled.xls* has a worksheet for the North American Geologic Map Data Model versions Lithology Class 4.3, 6.1, 6.2, and the State Geologic Map Compilation (SGMC) draft version represented by the abbreviations **lith43**, **lith6.2**, **lith6.1** and **SGMC**. The **Id** column allows for returning to the hierarchy after sorting alphabetically by term or by **R**, **G**, or **B**. The **Compiled_Lith** worksheet integrates the terminology and displays the color codes for all four worksheets, placing term variations within parenthesis.

Displayed below in legal size format that can be zoomed-in for detailed viewing are ArcMap® styles for the following:

- International Stratigraphic Chart (fig. 8)
- USGS Color Code (fig. 9)
- Decade of North American Geology (fig. 10)
- North American Geologic Map Data Model versions, lithclass 4.3 (fig. 11), lithclass 6.1 (fig. 12), and lithclass 6.2 (fig. 13)
- State Geologic Map Compilation (fig. 14).

Figure 7. Style for the International Stratigraphic Chart.

Figure 8. Style for the USGS Color Codes version of the International Stratigraphic Chart.

Figure 9. Style for the Decade of North American Geology 1983 Geologic Time Scale.

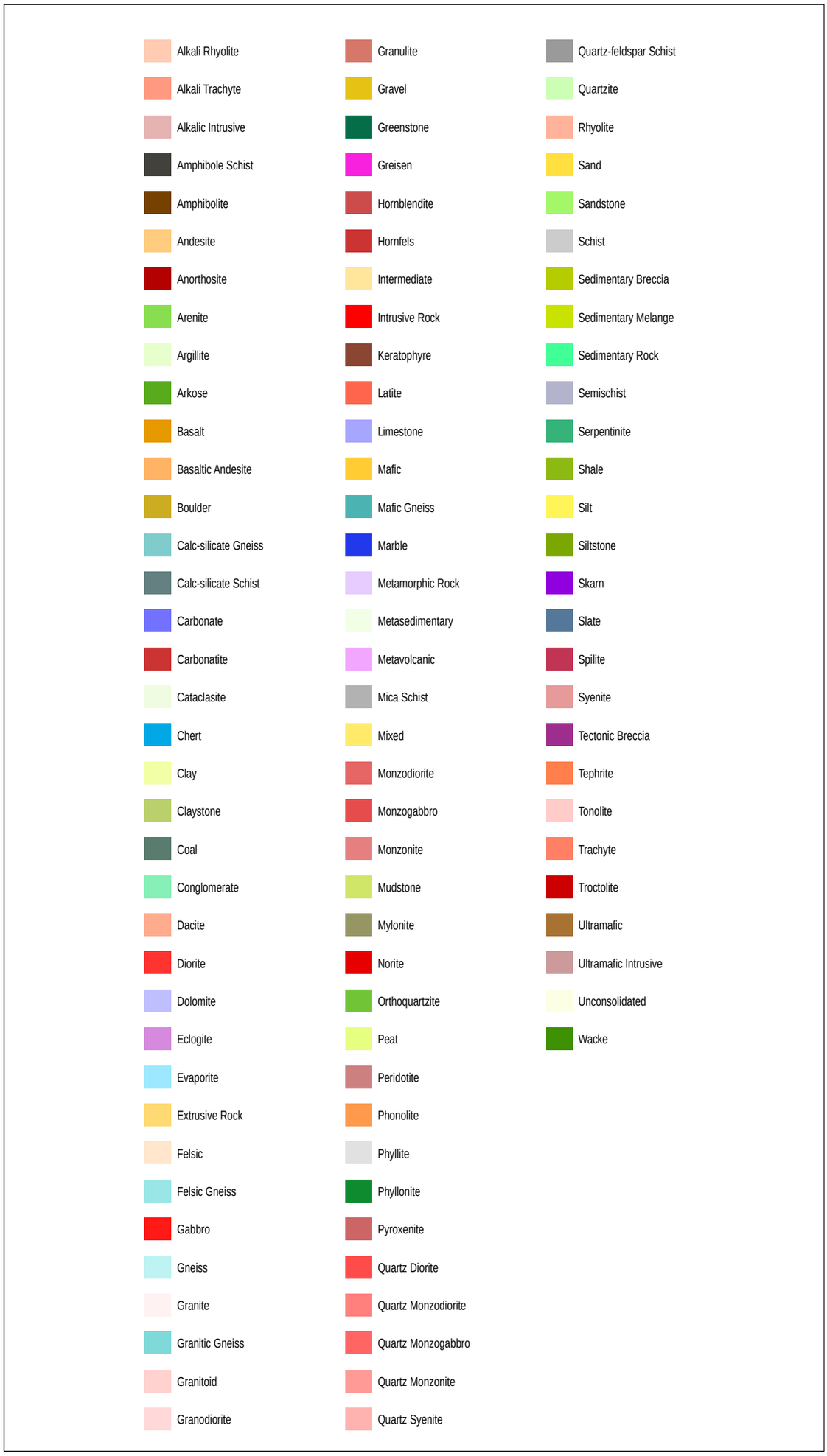

Figure 10. Style for the North American Geologic Map Data Model version lithclass 4.3 subset.

Figure 11. Style for the North American Geologic Map Data Model version lithclass 6.1.

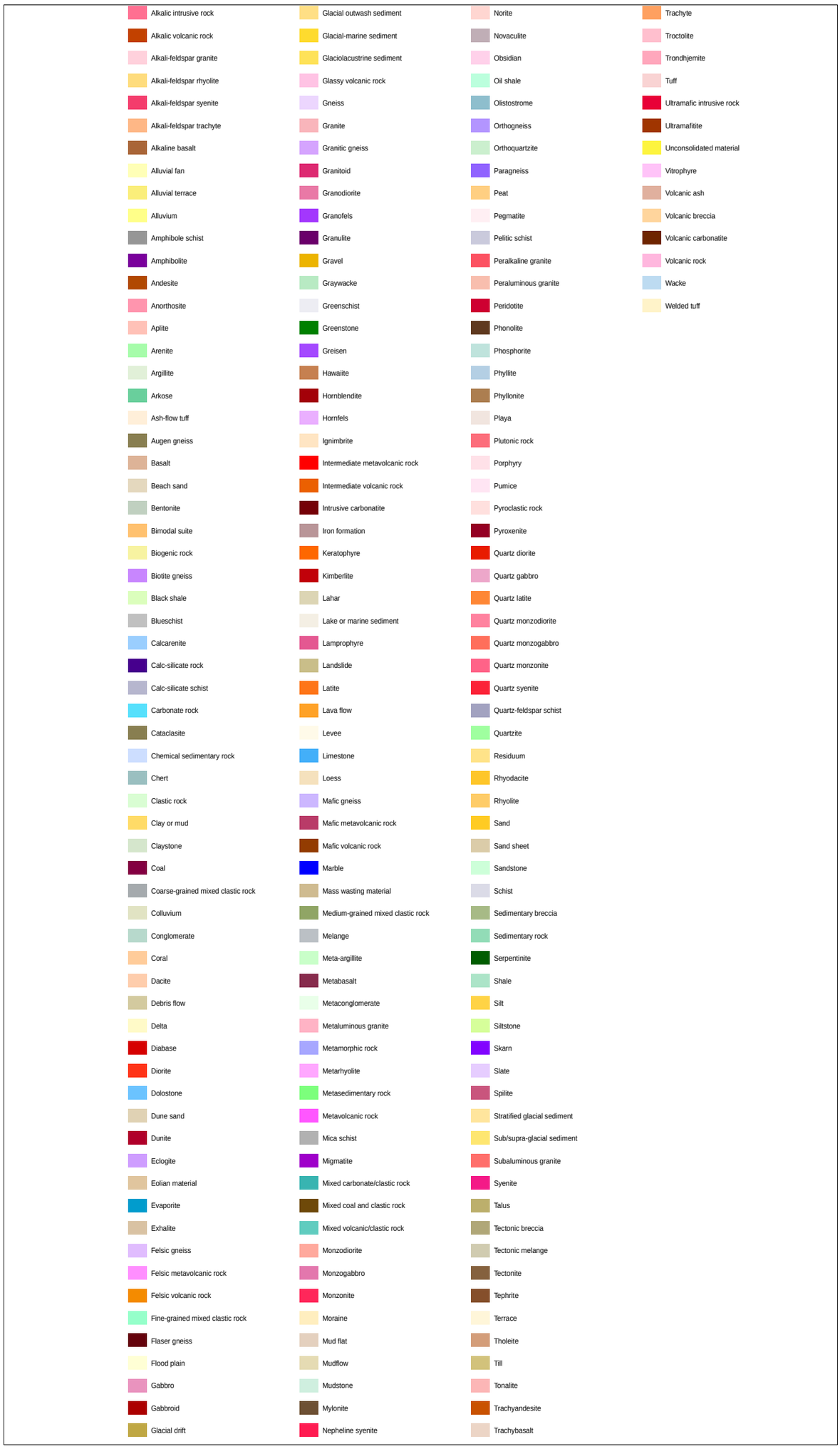

Figure 12. Style for the North American Geologic Map Data Model version lithclass 6.2.

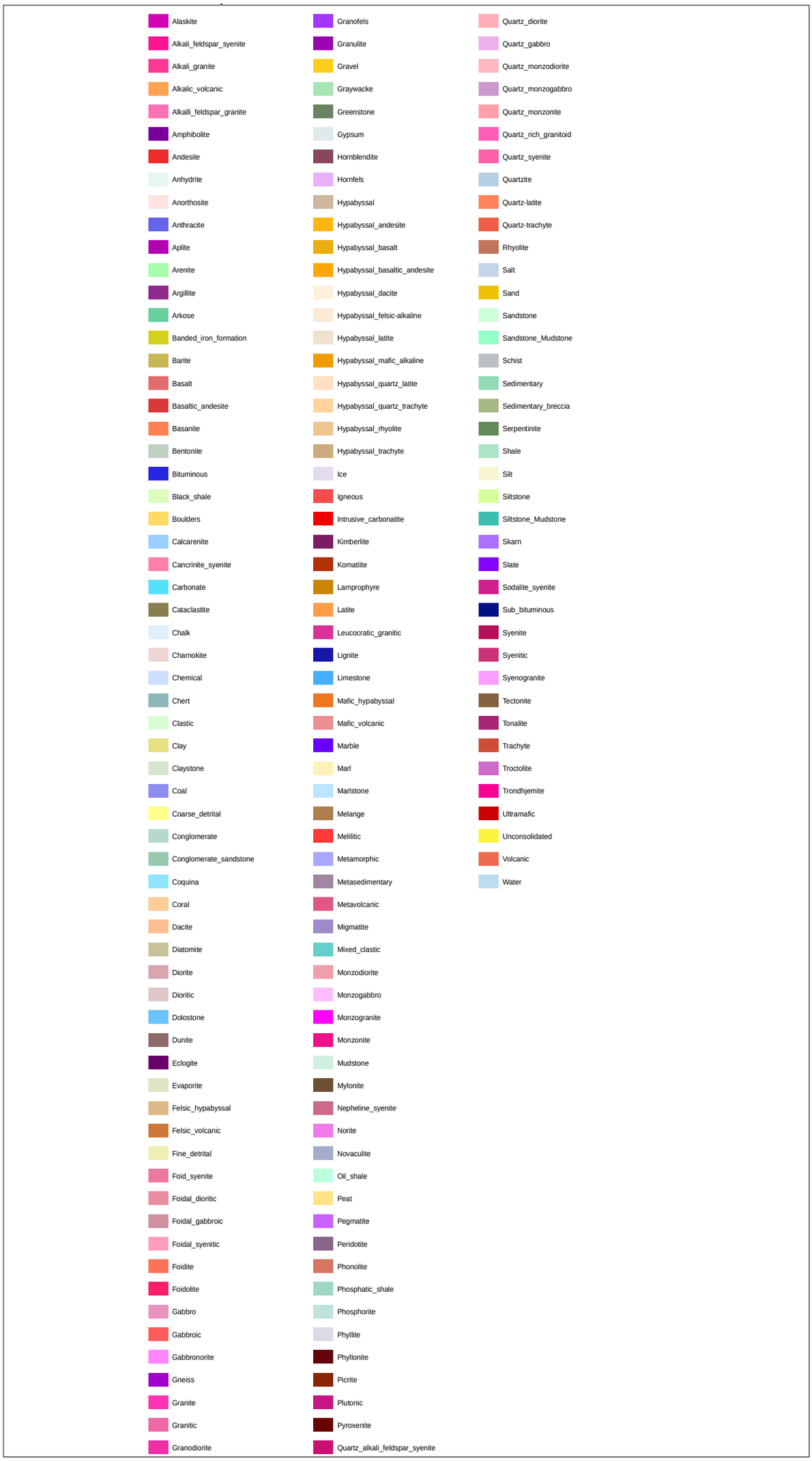

Figure 13. Style for the State Geologic Map Compilation (SGMC) draft version

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