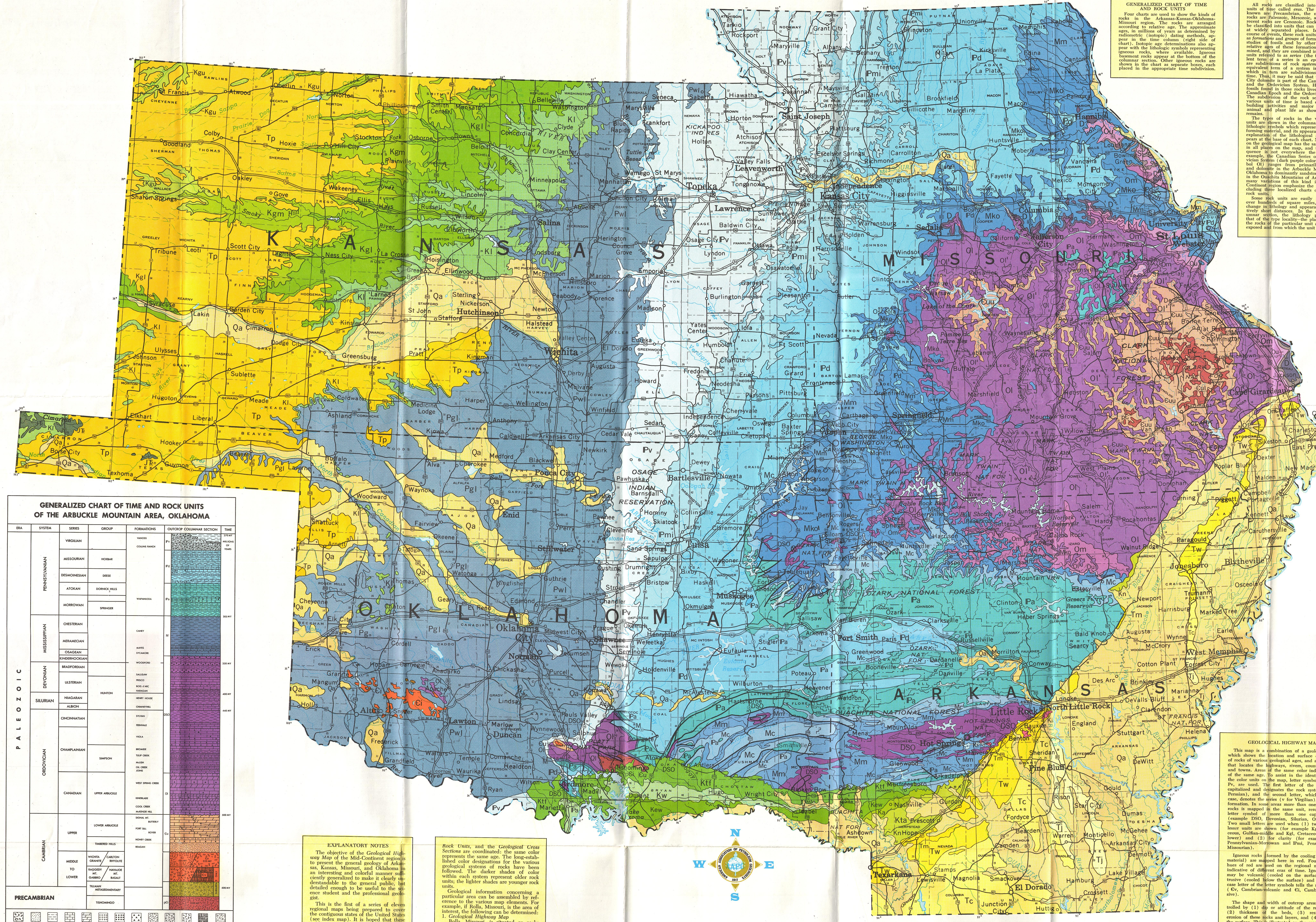


GENERALIZED CHART OF TIME AND ROCK UNITS

Four charts are used to show the kinds of rocks in the Arkansas-Kansas-Oklahoma-Missouri region. The rocks are arranged according to relative age. The approximate ages, in millions of years as determined by radiometric (isotopic) dating methods, appear in the time column (right side of chart). Isotopic age determinations also appear with the lithologic symbols representing igneous rocks, where available. Igneous basement rocks appear at the bottom of the columnar section. Other igneous rocks are shown in the chart as separate boxes, each placed in the appropriate time subdivision.

All rocks are classified into four major units of time called *eras*. The oldest rocks known are Precambrian, the next younger rocks are Paleozoic, Mesozoic, and the most recent rocks are Cenozoic. Rock layers may be classified into units that can be identified at widely separated places. In the usual course of events, these rock units are mapped as *formations* and *groups* of formations. From studies of fossils and by other means, the relative ages of these formations are determined, and they are combined into time-rock units referred to as *series* (the time equivalent term of a series is an *epoch*). Series are subdivisions of rock *systems* (the time equivalent term of a system is a *period*), which in turn are subdivisions of eras of time. Thus, it may be said that the Jefferson City dolomite is part of the Canadian Series and the Ordovician System. However, the fossils found in those rocks lived during the Canadian Epoch and the Ordovician Period. The subdivision of the rock sequence into various units of time is based on mountain building activities and major changes in animal and plant life as shown by fossil remains.

The types of rocks in the various map units are shown in the columnar section by lithologic symbols which represent the rock-forming material, and its appearance. A word explanation of the lithological symbols appears at the base of each chart. No map unit on the geological map has the same lithology in all places on the map, and the rock sequence is not everywhere the same. For example, the Canadian Series of the Ordovician System (dark purple color—letter symbol Ol) ranges from primarily limestone and dolomite in the Arbuckle Mountains of Oklahoma to dominantly sandstone and shale in the Ouachita Mountains of Arkansas. The many variations of this kind in the Mid-Continent region emphasize the need for including three localized charts of time and rock units.

Some rock units are easily recognizable over hundreds of square miles, but others change in lithology and appearance in relatively short distances. In the outcrop columnar section, the lithology presented is that of the type locality—the place at which the rocks of the particular unit are typically exposed and from which the unit was named.

GENERALIZED CHART OF TIME AND ROCK UNITS OF ARKANSAS-KANSAS-MISSOURI-OKLAHOMA

ERA	SYSTEM	SERIES	GROUP	FORMATIONS	OUTCROP COLUMNAR SECTION	TIME
CENOZOIC	QUATERNARY	RECENT			Qa	0 MILLIONS OF YEARS
		PLEISTOCENE	WISCONSIN STAGE	BIGNELL, PEORIA	Qp (UNMAPPED)	
			ILLINOIAN STAGE	LOVELAND		
			KANSAN STAGE	KANSAS		
			NEBRASKAN STAGE	NEBRASKA		1 MY
	TERTIARY	PLIOCENE		OGALLALA	Tp	11 MY
MESOZOIC	CRETACEOUS	GULFIAN	MONTANA	PIERRE	Kgu	70 MY
			COLORADO	NIOBRARA	Kgm	
				CARLILE, GREENHORN, GRANEROS	Kgl	
		COMANCHEAN	DAKOTA	OMADI (SUBSURFACE), KIOWA, CHEYENNE	Kl	
	JURASSIC			MORRISON	J♄	135 MY
	TRIASSIC			DOCKUM		180 MY
PALEOZOIC	PERMIAN	GUADALUPIAN		TALOGA	Pg	225 MY
				DAY CREEK, WHITEHORSE, BLAINE	Pgl	
		LEONARDIAN	NIPPEWALLA			
			SUMNER			
		WOLFCAMPIAN	CHASE		Pwl	
			COUNCIL GROVE			
			ADMIRE			270 MY
	PENNSYLVANIAN	VIRGILIAN	WABAUNSEE		IPv	
			SHAWNEE			
			DOUGLAS			
		MISSOURIAN	PEDEE		IPmi	
			LANSING			
			KANSAS CITY			
			PLEASANTON			
		DESMOINESIAN	MARMATON		IPd	
			CHEROKEE			
		ATOKAN		ATOKA	IPa	
		MORROWAN		WAPANUCKA, BLOYD, HALE		305 MY
	MISSISSIPPIAN	CHESTERIAN		PITKIN, FAYETTEVILLE, BATESVILLE, HINDSVILLE	Mc	
		MERAMECIAN		STE. GENEVIEVE, ST. LOUIS, SALEM, WARSAW	Mm	
		OSAGEAN	"BOONE"	KEOKUK, REEDS SPRING, ST. JOE	Mko	
		KINDERHOOKIAN	CHOUTEAU	SEDALIA, COMPTON, HANNIBAL, SYLAMORE		
	DEVONIAN	UPPER		CHATTANOOGA	D	
		MIDDLE		SNYDER CREEK, ST. LAURENT, BEAUVAIS		
		LOWER		GRAND TOWER, CLEAR CREEK, LITTLE SALINE, BAILEY		
	SILURIAN	NIAGARAN		BAINBRIDGE	S	
		ALEXANDRIAN		OSGOOD, BRASSFIELD, EDGEWOOD, GIRARDEAU		440 MY
	ORDOVICIAN	CINCINNATIAN		ORCHARD CREEK, THEBES, MAQUOKETA, FERNVALE	Ou	
		CHAMPLAINIAN		KIMMSWICK, DECORAH, PLATTIN, ROCK LEVEE, JOACHIM, ST. PETER, EVERTON	Om	
		CANADIAN		BLACK ROCK, SMITHVILLE, POWELL, COTTER	Ol	
			JEFFERSON CITY	THEODOSIA, RICH FOUNTAIN, ROUBIDOUX, GASCONADE	Ol'	500 MY
	CAMBRIAN	UPPER		EMINENCE, POTOSI	Єuu	
			ELVINS	DERBY-DOERUN, DAVIS, BONNETERRE	Єul	
				LAMOTTE		
PRECAMBRIAN					pЄ (1350 MY)	600 MY

CONGLOMERATE · SANDSTONE · LOESS · SHALE · MARL · LIMESTONE · DOLOMITE · OOLITE · GLAUCONITE · CHERT · ANHYDRITE · COAL · GRANITE · RHYOLITE · GABBRO

GENERALIZED CHART OF TIME AND ROCK UNITS OF THE ARBUCKLE MOUNTAIN AREA, OKLAHOMA

ERA	SYSTEM	SERIES	GROUP	FORMATIONS	OUTCROP COLUMNAR SECTION	TIME
PALEOZOIC	PENNSYLVANIAN	VIRGILIAN		VANOSS, COLLINS RANCH	IPv	270 MY MILLIONS OF YEARS
		MISSOURIAN	HOXBAR		IPd	
		DESMOINESIAN	DEESE			
		ATOKAN	DORNICK HILLS	WAPANUCKA	IPa	
		MORROWAN	SPRINGER			305 MY
	MISSISSIPPIAN	CHESTERIAN		CANEY	M	
		MERAMECIAN				
		OSAGEAN		MAYES		
		KINDERHOOKIAN		SYCAMORE		
	DEVONIAN	BRADFORDIAN		WOODFORD		350 MY
		ULSTERIAN	HUNTON	SALLISAW, FRISCO, BOIS d'ARC, HARAGAN		400 MY
	SILURIAN	NIAGARAN		HENRY HOUSE		
		ALBION		CHIMNEYHILL		440 MY
	ORDOVICIAN	CINCINNATIAN		SYLVAN, FERNVALE	DSO	
		CHAMPLAINIAN	SIMPSON	VIOLA, BROMIDE, TULIP CREEK, McLISH, OIL CREEK, JOINS		
		CANADIAN	UPPER ARBUCKLE	WEST SPRING CREEK, KINDBLADE, COOL CREEK, McKENZIE HILL	Ol	500 MY
	CAMBRIAN	UPPER	LOWER ARBUCKLE	SIGNAL MT., BUTTERLY, FORT SILL, ROYER	Єu	
			TIMBERED HILLS	HONEY CREEK, REAGAN		
		MIDDLE TO LOWER	WICHITA GRANITE / CARLTON RHYOLITE		Єi 525 MY, Єv 525 MY	
			RAGGEDY MT. GABBRO / NAVAJOE MT. BASALT		535 MY, Єv (SUBSURFACE ONLY)	
PRECAMBRIAN			TILLMAN METASEDIMENTARY			600 MY
			TISHOMINGO		pЄi 1350 MY	

CONGLOMERATE · SANDSTONE · SHALE · LIMESTONE · DOLOMITE · OOLITE · GLAUCONITE · CHERT · GRANITE · GABBRO · RHYOLITE · BASALT · METASEDIMENT

Example: Fort Smith, Ark. to Oklahoma City, Okla. 195 miles

	Altus, Okla.	Ardmore, Okla.	Bartlesville, Okla.	Blytheville, Ark.	Coffeyville, Kan.	Columbia, Mo.	Dallas, Tex.	Dodge City, Kan.	Duncan, Okla.	Durant, Okla.	El Dorado, Ark.	Enid, Okla.	Fayetteville, Ark.	Fort Smith, Ark.	Hannibal, Mo.	Hot Springs, Ark.	Hutchinson, Kan.	Independence, Mo.	Jefferson City, Mo.	Jonesboro, Ark.	Joplin, Mo.	Kansas City, Kan.-Mo.	Lawton, Okla.	Little Rock, Ark.	Manhattan, Kan.	McAlester, Okla.	Memphis, Tenn.	Muskogee, Okla.	Oklahoma City, Okla.	Omaha, Neb.	Pine Bluff, Ark.	Ponca City, Okla.	Rolla, Mo.	Salina, Kan.	St. Joseph, Mo.	St. Louis, Mo.	Sedalia, Mo.	Shreveport, La.	Springfield, Mo.	Stillwater, Okla.	Texarkana, Tex.-Ark.	Topeka, Kan.	Tulsa, Okla.
Ardmore, Okla.	159
Bartlesville, Okla.	310	259
Blytheville, Ark.	678	519	378
Coffeyville, Kan.	301	260	44	416
Columbia, Mo.	565	554	372	363	313
Dallas, Tex.	195	108	367	520	345	602
Dodge City, Kan.	245	368	314	688	308	498	467
Duncan, Okla.	85	73	228	605	272	532	181	330
Durant, Okla.	213	55	227	477	248	522	97	404	128
El Dorado, Ark.	484	325	416	315	459	526	277	658	392	264
Enid, Okla.	211	185	128	565	172	450	293	215	135	230	495
Fayetteville, Ark.	347	295	163	323	151	294	332	446	329	233	301	238
Fort Smith, Ark.	320	220	176	331	212	355	276	458	268	172	240	259	61
Hannibal, Mo.	661	637	427	310	390	101	672	566	649	593	578	518	395	428
Hot Springs, Ark.	436	278	189	254	346	412	304	592	359	223	121	393	195	134	535
Hutchinson, Kan.	342	333	213	584	204	352	432	126	286	358	621	176	347	376	418	510
Independence, Mo.	472	275	52	454	170	130	505	368	430	415	549	320	247	305	198	435	222
Jefferson City, Mo.	532	527	312	330	280	33	565	508	540	490	474	447	261	318	110	413	383	140
Jonesboro, Ark.	609	450	436	59	355	304	561	629	557	418	256	502	264	289	343	195	525	389	271
Joplin, Mo.	341	316	101	352	64	251	360	364	323	254	395	229	87	155	321	277	260	149	211	351
Kansas City, Kan.-Mo.	472	443	223	454	163	136	499	362	424	409	543	314	242	303	204	437	216	11	146	395	155
Lawton, Okla.	57	101	227	611	269	529	191	302	32	152	416	149	352	291	602	375	283	419	542	580	282	413
Little Rock, Ark.	495	334	342	195	365	406	325	611	410	282	120	412	214	153	458	59	533	399	354	136	273	405	444
Manhattan, Kan.	342	393	252	571	204	253	504	258	346	418	645	236	337	405	319	539	130	123	263	512	250	117	343	510
McAlester, Okla.	224	123	167	444	188	468	174	388	155	77	331	208	174	113	501	204	318	341	437	402	180	335	178	263	388
Memphis, Tenn.	634	473	481	63	423	426	464	750	549	421	229	541	353	292	399	198	589	453	336	68	357	459	583	139	580	402
Muskogee, Okla.	270	188	102	408	120	366	239	377	205	140	317	183	65	77	436	211	270	276	326	366	115	270	237	230	324	65	369
Oklahoma City, Okla.	125	103	159	526	203	467	215	263	69	141	387	82	222	195	536	329	217	353	426	484	216	347	66	349	277	125	479	145
Omaha, Neb.	560	538	343	648	295	331	650	414	534	539	738	427	437	498	338	632	318	201	345	590	350	195	531	600	188	479	654	465	435
Pine Bluff, Ark.	509	351	387	198	410	451	345	656	432	296	94	466	259	198	503	73	578	467	399	181	318	473	448	45	555	277	135	284	393	645
Ponca City, Okla.	230	208	69	447	113	441	310	245	189	216	470	67	232	233	496	367	145	289	381	496	172	292	203	386	205	194	515	154	105	396	456
Rolla, Mo.	537	497	296	265	243	98	546	517	503	453	397	410	224	281	175	342	413	209	65	206	196	215	463	277	328	361	262	289	393	410	387	351
Salina, Kan.	373	364	244	615	235	332	475	194	317	389	652	207	378	407	398	541	66	202	327	556	291	196	314	564	64	390	655	326	248	220	609	176	409
St. Joseph, Mo.	507	495	275	506	236	188	551	389	451	461	577	341	294	355	195	489	239	58	202	447	207	52	448	457	133	420	511	322	376	143	502	310	267	197
St. Louis, Mo.	633	614	395	205	356	124	645	614	616	566	473	523	337	393	105	412	480	246	130	238	307	252	583	353	377	473	294	401	506	455	398	464	112	456	306
Sedalia, Mo.	525	504	289	386	250	68	539	444	445	445	463	417	231	288	169	349	298	76	56	327	191	82	473	373	199	368	383	306	407	277	388	358	121	278	134	186
Shreveport, La.	383	286	453	398	476	617	188	621	369	242	94	440	325	264	669	176	575	562	569	347	413	568	379	211	669	310	335	341	358	763	188	429	532	622	620	564	542
Springfield, Mo.	411	390	175	278	136	177	425	410	396	346	349	303	117	174	247	235	306	170	144	219	74	176	356	229	293	254	283	182	286	371	274	244	107	372	227	220	114	425
Stillwater, Okla.	191	169	79	533	123	433	266	289	147	175	449	60	192	202	506	343	186	308	396	456	185	302	132	361	256	152	491	117	66	447	407	41	384	227	354	479	368	452	259
Texarkana, Tex.-Ark.	383	231	352	350	403	561	179	564	298	170	94	383	252	191	612	120	518	489	509	291	340	495	322	155	596	237	294	268	301	690	159	372	472	549	547	508	469	73	365	329
Topeka, Kan.	421	412	198	517	150	199	505	279	365	394	591	255	283	351	265	485	153	69	209	458	196	63	362	456	54	334	522	270	290	145	501	224	276	133	86	315	145	609	239	275	536
Tulsa, Okla.	229	185	54	466	75	359	271	328	214	173	375	120	118	135	435	269	246	264	324	382	109	258	218	287	275	113	417	49	104	366	333	95	310	298	302	404	300	378	182	74	311	221
Wichita, Kan.	282	273	153	524	144	338	384	164	226	298	561	116	287	316	402	450	60	204	344	465	200	198	223	473	120	299	529	235	157	311	518	85	353	91	225	450	280	515	246	136	458	139	186

EXPLANATORY NOTES

The objective of the *Geological Highway Map* of the Mid-Continent region is to present the general geology of Arkansas, Kansas, Missouri, and Oklahoma in an interesting and colorful manner sufficiently generalized to make it clearly understandable to the general public, but detailed enough to be useful to the science student and the professional geologist.

This is the first of a series of eleven regional maps being prepared to cover the contiguous states of the United States (see index map). It is hoped that these publications will be a valuable source of geological information that will be used by the traveling public to help explain the variations seen in rocks, soils, and landforms. All landforms, such as river valleys, hills, plateaus, canyons, plains, and mountains, result from geological processes and take on new beauty and fascination when they are observed with some understanding of their origin and history.

Each of the illustrations in this publication presents a particular type of geological information, and each is in part related to the other. The *Geological Highway Map* shows, by different colors, the age and outcrop pattern of the surface rocks. The *Generalized Chart of Time and Rock Units* illustrates the kinds of rocks that comprise the map units and their relative and radiometric ages (determined from decay of radioactive elements in the rocks). The positions of the principal structural features are presented on the *Tectonic Map*. The rocks and structure below the surface are shown on the *Geological Cross Sections*. The principal landforms are illustrated on the *Physiographic Map*.

All colors on the *Geological Highway Map*, the *Generalized Chart of Time and Rock Units*, and the *Geological Cross Sections* are coordinated: the same color represents the same age. The long-established color designations for the various geological systems of rocks have been followed. The darker shades of color within each system represent older rock units; the lighter shades are younger rock units.

Geological information concerning a particular area can be assembled by reference to the various map elements. For example, if Rolla, Missouri, is the area of interest, the following can be determined:

1. *Geological Highway Map*
Rolla, Missouri, is situated on rocks whose age and outcrop pattern are shown by the dark purple color and the letter symbol Ol.
2. *Generalized Chart of Time and Rock Units*
The dark purple color and letter symbol Ol indicate that these rocks are of the Paleozoic Era, Ordovician System, and Canadian (Lower Ordovician) Series. The lithologic symbols show that the surface rocks are primarily cherty limestone and dolomite. The time column places the age of these rocks at approximately 500 million years.
3. *Geological Cross Sections*
Cross section F¹-F² passes through Rolla, Missouri, and shows that Rolla is located on rocks of the Jefferson City Group. The essentially horizontal layers of sedimentary rocks of Ordovician and Cambrian age are approximately 1,500 feet thick and rest on Precambrian granites.
4. *Physiographic Map*
Rolla is located on the Salem Upland of the Ozark Plateau.
5. *Tectonic Map*
Rolla is situated on the Ozark uplift.

Similarly, geological information can be obtained for any area in the four-state region.

PRINCIPAL SOURCES OF MAP INFORMATION

Geology adapted from the Geologic Map of the United States (U.S.G.S., 1932), the Tectonic Map of the United States (U.S.G.S.-A.A.P.G., 1962), and the State Geologic Maps of Arkansas (A.G.S., 1929), Kansas (K.G.S., 1937), Missouri (M.G.S., 1961) and Oklahoma (U.S.G.S.-O.G.S., 1954). Base map adapted from Map of the United States (Congress of the United States, compiled by U.S.G.S., 1964). Highway network adapted from Federal-Aid Highway Map of the United States, (U.S. Dept. of Commerce, compiled by U.S.G.S., 1965).

GENERALIZED CHART OF TIME AND ROCK UNITS OF THE OUACHITA MOUNTAINS, OKLAHOMA - ARKANSAS

ERA	SYSTEM	SERIES	GROUP	FORMATIONS	OUTCROP COLUMNAR SECTION	TIME
PALEOZOIC	PENNSYLVANIAN	ATOKAN		ATOKA	IPa	MILLIONS OF YEARS
		MORROWAN		WAPANUCKA		305 MY
	MISSISSIPPIAN	CHESTERIAN	JACKFORK	JOHNS VALLEY, GAME REFUGE, WESLEY, MARKHAM MILL, PRAIRIE MT., WILDHORSE MT.	Mc	
		MERAMECIAN	STANLEY	CHICKASAW CREEK, MOYERS, TEN MILE CREEK	Mm	
		OSAGEAN				
		KINDERHOOKIAN		ARKANSAS NOVACULITE		350 MY
	DEVONIAN	UPPER				
		MIDDLE				
		LOWER		PINETOP		400 MY
	SILURIAN	NIAGARAN		MISSOURI MT., BLAYLOCK		440 MY
	ORDOVICIAN	CINCINNATIAN		POLK CREEK, BIGFORK	DSO	
		CHAMPLAINIAN		WOMBLE		
		CANADIAN		BLAKELY, MAZARN, CRYSTAL MT., COLLIER, LUKFATA		500 MY

SANDSTONE · SHALE · LIMESTONE · OOLITE · GLAUCONITE · CHERT

GENERALIZED CHART OF TIME AND ROCK UNITS OF SOUTHERN ARKANSAS AND OKLAHOMA

ERA	SYSTEM	SERIES	GROUP	FORMATIONS	OUTCROP COLUMNAR SECTION	TIME
CENOZOIC	QUATERNARY				Qa	0, 1 MY
	TERTIARY	EOCENE	JACKSON		Tj	40 MY, MILLIONS OF YEARS
			CLAIBORNE		Tc	
			WILCOX		Tw	
			MIDWAY	PORTERS CREEK, CLAYTON	Tm	70 MY
MESOZOIC	CRETACEOUS (Ki IGNEOUS INTRUSIVE)	GULFIAN	NAVARRO	ARKADELPHIA, NACATOCH, SARATOGA, MARLBROOK	Kn	
			TAYLOR	ANNONA, OZAN, BROWNSTOWN	Kta	
			AUSTIN—EAGLE FORD	TOKIO-EAGLE FORD	Ka	
			WOODBINE	WOODBINE	Kew	
		COMANCHEAN	WASHITA	GRAYSON, MAIN STREET, PAWPAW, WENO, DENTON, FT. WORTH, DUCK CREEK, KIAMICHI	Kw	
			FREDERICKSBURG	GOODLAND, PALUXY	Ktf	
			TRINITY	"TRINITY": MOORINGSPORT, FERRY LAKE, RODESSA, PINE ISLAND, SLIGO		
			COAHUILA	HOSSTON		135 MY
	JURASSIC			COTTON VALLEY, BUCKNER, SMACKOVER, EAGLE MILLS	J (SUBSURFACE ONLY)	180 MY

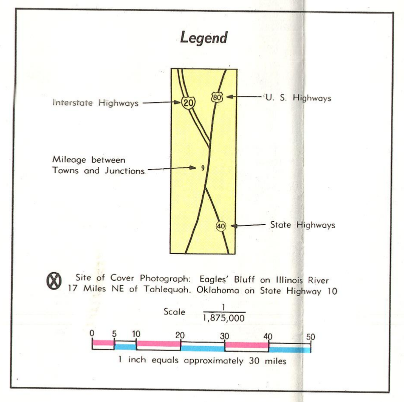
CONGLOMERATE · SANDSTONE · SHALE · MARL · CHALK · LIMESTONE · ANHYDRITE · SALT · Ki NEPHELITE SYENITE

GEOLOGICAL HIGHWAY MAP

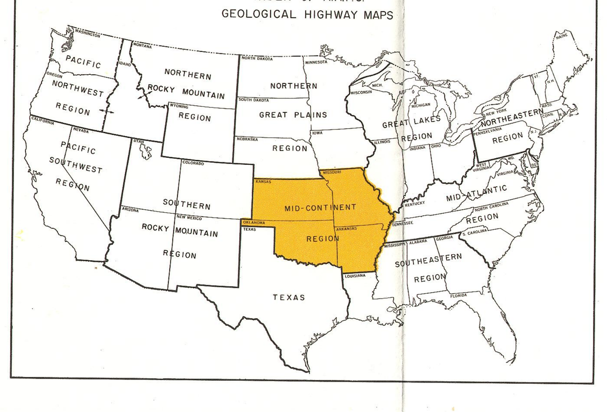
This map is a combination of a geological map which shows the location and surface distribution of rocks of various geological ages, and a base map that locates the highways, rivers, counties, cities, and towns. Areas of the same color indicate rocks of the same age. To assist in the identification of the color units on the map, letter symbols, such as Pv, are used. The first letter of the symbol is capitalized and designates the rock system (P for Permian), and the second letter, which is lower case, denotes the series (v for Virgilian), group, or formation. In some areas more than one system of rocks is mapped in the same unit, resulting in a letter symbol of more than one capital letter (example DSO, Devonian, Silurian, Ordovician). Two small letters are used when (1) two or more lesser units are shown (for example Kgm, Cretaceous, Gulfian-middle and Kgl, Cretaceous-Gulfian-lower) and (2) for clarity (for example, IPm, Pennsylvanian-Morrowan and IPmi, Pennsylvanian-Missourian).

Igneous rocks (formed by the cooling of molten material) are mapped here in red. Four different hues of red are used on the regional maps, each indicative of different eras of time. Igneous rocks may be volcanic (cooled on the surface) or intrusive (cooled below the surface) and the lower case letter of the letter symbols tells the rock origin (Єv, Cambrian-volcanic and Єi, Cambrian-intrusive).

The shape and width of outcrop areas are controlled by (1) dip or attitude of the rock layers, (2) thickness of the beds, (3) resistance to erosion of these rocks and layers, and (4) slope of the surface. This is illustrated on the cross sections.



INDEX OF A.A.P.G. GEOLOGICAL HIGHWAY MAPS



MAP NO. 1

UNITED STATES GEOLOGICAL HIGHWAY MAP SERIES

Geological Highway Map of the MID-CONTINENT REGION

KANSAS · OKLAHOMA · MISSOURI · ARKANSAS

COMPILED BY
PHILIP OETKING
GRADUATE RESEARCH CENTER OF THE SOUTHWEST
DAN E. FERAY
TEXAS CHRISTIAN UNIVERSITY
H. B. RENFRO
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