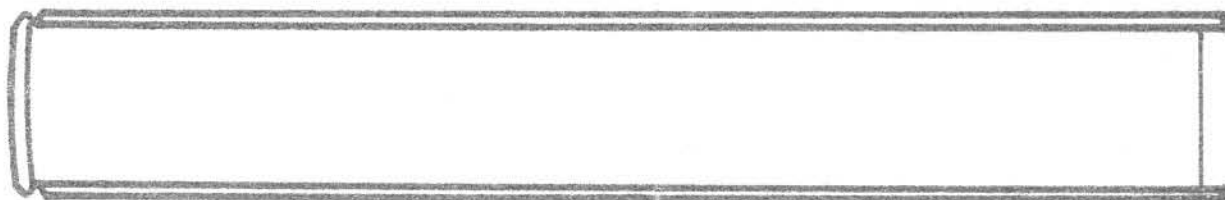


1959-1973  
annotated bibliography  
of  
**MISSOURI  
PRECAMBRIAN**

by eva b. kisvarsanyi



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ANNOTATED BIBLIOGRAPHY OF MISSOURI PRECAMBRIAN,  
1959-1973

by  
Eva B. Kisvarsanyi

October, 1973

Missouri Geological Survey and Water Resources  
Wallace B. Howe, State Geologist and Director  
Rolla, Missouri 65401



## Introduction

This bibliography was prepared in order to assist those interested in the Precambrian geology of Missouri. It lists published and unpublished papers that were issued between 1959 and 1973. A few papers that appeared before 1959 but were not included in a previous bibliography (Wills and Bertram, 1959) are also listed. Both bibliographies should be consulted for a complete list of references on the Missouri Precambrian.

References pertinent to both exposed and buried Precambrian rocks of Missouri are listed in this bibliography. Geophysical investigations and regional studies covering all or parts of Missouri are included inasmuch as they are pertinent to the definition and interpretation of basement structures.

Those references that are available in the library and manuscript file of the Missouri Geological Survey were reviewed by the writer; those that were not available for review are so indicated. Some of the latter titles may prove to be irrelevant to the subject of this bibliography.



Aldrich, L. T., 1957, The measurement and application of mineral ages: American Geophysical Union Trans., v. 38, n. 3, p. 385.

Feldspars in Graniteville granite dated by Rb/Sr method, gave age of 1,300 to 1,400 m.y.

Aldrich, L. T., G. W. Wetherill, M. N. Bass, W. Compston, G. L. Davis and G. R. Tilton, 1959, Mineral age measurements: Ann. Rept. Carnegie Inst. Washington, Yearbook 58, p. 237-250.

"Age determination directed toward the location in time and space of the great Precambrian mountain chains or orogenic belts are reported...", including igneous rocks from southern Missouri. Not available for review. Quoted from Lidiak and Denison, 1963.

Aldrich, L. T., G. W. Wetherill, M. N. Bass, G. R. Tilton and G. L. Davis, 1960, Mineral age measurements and earth history: Ann. Rept. Dept. Terrestrial Magnetism, Carnegie Inst. Washington, Yearbook 59, p. 208-221.

Mineral ages from basement wells are reported from Missouri and other states. Not available for review.

Algermissen, Sylvester Theodore, 1961, Underground and surface gravity survey, Leadwood, Missouri: Geophysics, v. 26, n. 2, p. 158-168.

Not available for review. Density measurements on Missouri Precambrian rocks are reported.

Allen, Harry John, 1969, A gravity and aeromagnetic interpretation of the Decaturville dome area, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis Missouri.

Following 15-min. quadrangles included: Fristoe, Warsaw, Little Niangua, Linn Creek, Hermitage, Urbana, Macks Creek, Stoutland. Dome underlain by low density granite batholith, emplaced along NW trending zone of weakness; older Precambrian basement around batholith is siliceous with complex igneous history, includes dikes and felsite roof pendants; Decaturville cryptoexplosion structure has only minor expression in the geophysical data. - M.G.S. manuscript file.

Allen, V. T., P. M. Hurley, H. W. Fairbairn and W. H. Pinson, 1959, Age of Precambrian igneous rocks of Missouri (abs.): Geol. Soc. America Bull., v. 70, n. 12, pt. 2, p. 1560.

Mica ages, four from outcrop (Graniteville and Silvermine granites, 1,200 to 1,350 m.y.), and one from the subsurface (Orla diorite, 1,150 m.y.) determined by K/Ar method.

Allen, William H., James A. Martin and David L. Rath, 1973, First-look analysis of geologic ground patterns on ERTS-1 imagery of Missouri in Symposium on significant results obtained from the ERTS-1, v. 1, sec. A: National Aeronautics and Space Admin., Washington, D. C., p. 371-378.

Several known geologic features can be identified on ERTS-1 imagery in eastern Missouri; some of the suspected Precambrian lineaments are sharply defined and can be extended. - M.G.S. library.

Allingham, John W., 1960, Interpretation of aeromagnetic anomalies in southeast Missouri in Geological Survey research: U. S. Geol. Survey Prof. Paper 400-B, p. B216-B219.

Aeromagnetic data in southeast Missouri found useful in basement mapping (gross lithology, buried knobs and ridges, faults, contacts, potential magnetite deposits).

\_\_\_\_\_, 1964, Low amplitude aeromagnetic anomalies in southeastern Missouri: Geophysics, v. 29, n. 4, p. 537-552.

Not available for review.

\_\_\_\_\_, 1966, Aeromagnetic anomalies in the Bonne Terre area of the southeast Missouri mining district in Mining Geophysics, v. 1, Case Histories: Tulsa, Oklahoma, Soc. Explor. Geophysicists, p. 36-53.

Interpretative techniques (downward continuation, vertical derivatives, and residual anomalies) used on total-intensity aeromagnetic data. Downward continuation yields best correlation between ore deposits and magnetic anomalies, and best defines buried basement topography, as established in areas of reliable subsurface control. - M.G.S. library.

American Geophysical Union and U. S. Geological Survey, 1964, Bouguer gravity anomaly map of the United States (Exclusive of Alaska and Hawaii): U. S. Geol. Survey, 2 sheets, scale 1:2,500,000.

Geophysical map.

Amos, Dewey H. and George A. Desborough, 1970, Mafic intrusive rocks of Precambrian age in southeast Missouri (Contribution to Precambrian Geology No. 3): Mo. Geol. Survey and Water Resources, Rept. Inv. 47, 22 p.

Mafic sills and dikes mapped in portions of Iron-ton and Fredericktown 15-min. quadrangles; rhythmic layering and igneous lamination recognized and described, supplemented by petrographic, XRD, and XRF analyses; genetic relationship to iron mineralization suggested; total intensity and second derivative magnetic maps show fair correlation with geological data.



Anderson, Jay Earl, Jr., 1967, Petrographic features of some texturally altered welded tuffs (abs.): Geol. Soc. America, Program 1967 Ann. Mtgs., p. 6.

Progressive alteration of welded tuffs and development of "snowflake" texture is described from Tertiary rhyolite in Davis Mountains, Texas. Comparison with Carlton rhyolite (Cambrian) and Precambrian volcanics of St. Francois Mountains indicates that most of these rocks are texturally altered ignimbrites.

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\_\_\_\_\_, 1970a, Recognition and time distribution of texturally altered welded tuff: Geol. Soc. America Bull., v. 81, n. 1, p. 287-292.

Lack of recognition of Precambrian welded tuff accounts for its scarcity in literature. Widespread occurrence, broken phenocrysts, compaction foliation, snowflake texture, and lithophysal zones are considered diagnostic criteria in St. Francois Mountains volcanics. Well defined shards are rare.

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\_\_\_\_\_, 1970b, Snowflake texture not diagnostic of devitrified ash-flow tuffs: Reply: Geol. Soc. America Bull., v. 81, n. 8, p. 2529-2530.

Reply to Green, 1970. Additional data from the Missouri rocks support their ash-flow origin (crushed pumice fragments, vertical variations of phenocryst content). Some evidences for lava-flow origin (lineation of phenocrysts, autobrecciated zones, absence of shards) can also be applied to rheoignimbrites. The fundamental problem is considered to be the origin of widespread rhyolites exhibiting characteristics both of lava-flow rock and ash-flow tuff.

Anderson, Jay Earl, M. E. Bickford, R. E. Anderson, A. L. Odom and A. W. Berry, 1969, Precambrian volcanic terrane of the St. Francois Mountains, Missouri (abs.): Geol. Soc. America, Abstracts with Programs for 1969, Part 2, South-Central Sec., p. 1.

Whole rock Rb/Sr measurements indicate two igneous episodes, involving both intrusive and extrusive activity, at 1,415 and 1,320 m.y. ago. Major volcanic subsidence structure, the Taum Sauk Caldera, is defined.

Anderson, Jay Earl, M. E. Bickford, A. L. Odom and A. W. Berry, 1969, Some age relations and structural features of the Precambrian volcanic terrane, St. Francois Mountains, southeastern Missouri: Geol. Soc. America Bull., v. 80, p. 1815-1818.

More detailed discussion of the Rb/Sr geochronology and of geologic relationships in the area of the Taum Sauk Caldera. Extension of this shallow intrusive-volcanic terrane beneath younger sediments from western Ohio to the Texas panhandle is suggested.

Anderson, R. Ernest, 1962a, Pyroclastic flows of the Missouri Precambrian (abs): Geol. Soc. America, Special Paper 73, p. 105.

A mile-thick sequence of high-silica ash-flow and ash-fall tuffs is recognized through field, petrographic, and chemical studies.

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\_\_\_\_\_, 1962b, Igneous petrology of the Taum Sauk area, Missouri: Unpubl. Doctoral dissertation, Washington Univ., St. Louis, Missouri.

Precambrian rocks exposed within a 50 square mile area in parts of the Ironton and Edgehill 15-min quadrangles are mapped in detail. The area represents a portion of an elongated volcano-tectonic depression filled with extrusives and intruded by gabbro and granite porphyry. The volcanic section is recognized as a sequence of sheet-like pyroclastic flows (ash-flows, ignimbrites), more than a mile thick, separated by bedded air-fall tuffs. The sequence is divided into 13 map units comprised of 21 lithologic units. The rock forming materials were erupted from fissures associated with NE and NW trending fault systems; source areas are located to the E and NE of the mapped area. Characteristic textures and structures common to pyroclastic rocks from younger volcanic terranes are recognized and described through petrographic studies. The role of exsolved and entrapped volatiles in increasing flow mobilities and producing distinctive textures and fabrics is considered more important than previously recognized; volatiles were a major factor in reconstituting the iron oxide mineral assemblage, affecting magnetic and paleomagnetic properties. Ten new chemical analyses are presented. The structural province is typically anorogenic, and the petrologic province is typically alkaline. It is suggested that the rocks are acid differentiates of a deep-seated lopolith. - M.G.S. manuscript file.

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\_\_\_\_\_, 1970, Ash-flow tuffs of Precambrian age in southeast Missouri (Contribution to Precambrian Geology No. 2): Mo. Geol. Survey and Water Resources, Rept. Inv. 46, 50 p.

This report incorporates additional mapping and some revisions of the earlier work (Anderson, 1962). The geologic map covers an area of about 150 square miles in west-central St. Francois Mountains; ten major cartographic units are shown, some of which are subdivided. The volcanic sequence includes at least 11 cooling units; it accumulated in an extracaldera environment. The volcanic strata form a broad depression, the Taum Sauk depression, viewed as a downwarped roof segment of a batholithic mass of regional proportions. "Pervasive" hydrothermal alteration of the rocks is described and is related to the formation of iron ore deposits in the region. The bulk of the original volcanic rocks were rhyolitic with peralkaline affinities.

Anderson, R. Ernest and LeRoy Scharon, 1961, Notes on the geology of the Taum Sauk area in Guidebook to the geology of the St. Francois Mountain area; Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 119-121.

Preliminary report. Current mapping emphasizes detailed volcanic stratigraphy and structural geology. Variations in primary structures and textures used as a guide in mapping individual flow units. Two generations of faulting recognized.

Baker, John Hudson, 1967, Aeromagnetic investigations in southeast Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Interpretation includes Boss, Edgehill, Corridon, and Lesterville 15-min. quadrangles. Black fault zone interpreted to be Paleozoic adjustment along intra-basement fault zone of regional extent; Boss-Bixby anomaly interpreted to be caused by a dike-like basic intrusive; Belleview anomaly suggests the presence of a granite intrusive of large vertical extent. - M.G.S. manuscript file.

Ballantyne, Edwin J., Jr., 1961, A geophysical investigation of an area in Christian County, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Ground magnetic and gravimetric survey over a known magnetic anomaly. Source of the anomaly calculated to be at a depth of 4,000 feet below the surface, or about 1,600 feet below the buried Precambrian surface. - M.G.S. manuscript file.

Bass, M. N., 1960, Grenville boundary in Ohio: Jour. Geology, v. 68, p. 673-677.

Basement rocks west of the Grenville boundary penetrate unmetamorphosed volcanic and granitic rocks in central United States, are similar to those exposed in St. Francois Mountains, and are believed to comprise a non-orogenic igneous province older than Grenville in age. A table gives data on 14 basement wells in Ohio.

Bayley, R. W. and W. R. Muehlberger, compilers, 1968, Basement rock map of the United States (exclusive of Alaska and Hawaii): U. S. Geol. Survey, 2 sheets, scale 1:2,500,000.

Distinguish essentially two-fold division for Missouri: supracrustal acid igneous rocks, and batholithic igneous rocks.

Beckham, Wallace, Jr., 1964a, The gravity and magnetic fields of the Iron Mountain ore body: Unpubl. Masters thesis, Washington Univ., St. Louis Missouri.

Not available for review.

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\_\_\_\_\_, 1964b, Remanent magnetization in the interpretation of magnetic anomalies (abs.): Missouri Acad. Sci., Proceedings, v. 1, ser. 2, p. 37-38.

Calculation of theoretical magnetic anomaly of the Iron Mountain ore body. Theoretical reproduction of the observed anomaly could only be achieved by considering the complex history of mineralization and two periods of hydrothermal activity, which produced separate deposits of magnetite and hematite. Better results were achieved by accounting for remanent components of differing direction in the magnetite and hematite distributions.

Berry, Archie W., Jr., 1970, Precambrian volcanic rocks associated with the Taum Sauk caldera, St. Francois Mountains, Missouri: Unpubl. Doctoral dissertation, Univ. of Kansas, Lawrence, Kansas.

Precambrian geologic map of parts of the Graniteville and Ironton 7½-min. quadrangles. Establishes volcano-stratigraphic sequence (detailed descriptions and modal analyses of map units are included in Appendix) in the NE segment of the Taum Sauk Caldera; reverse movement along ring fractures and complexly faulted central region indicate resurgent central dome of the caldera. Most of the volcanic rock units mapped are believed to have been derived from the same magma chamber. The volcanic and associated plutonic rocks are assumed to be representative of a belt of similar Precambrian basement rocks extending from Ohio to Texas, and that may be a belt of continental accretion. - M.G.S. manuscript file.

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\_\_\_\_\_, 1971, Rhyolite with vertical flow banding associated with rhyolitic ash-flow tuff, St. Francois Mountains, Missouri (abs.): Geol. Soc. America, Abstracts with Programs, v. 3, n. 1, p. 18.

Petrographic description of vertical flow banding in a basal rhyolite lava flow that is overlain by massive rhyolitic ash-flow tuff. Banding is attributed to concentration of gases along shear planes developed during flow in the highly gaseous and viscous lava.

Beyer, John Henry, Jr., 1969, Basement structure on the western flank of the Ozark uplift, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Area of investigation bounded by 92°00 and 93°30' W longitude, and by 36°30' and 37°40' N latitude, including aeromagnetic maps of Bolivar, Buffalo, Morrisville, and Strafford 15-min. quadrangles. Geophysical data (gravity, magnetic, and seismic) are utilized to determine the basement structure. Four gravity provinces are distinguished and discussed, and the geologic history of the basement complex is interpreted. - M.G.S. manuscript file.

Bickford, M. E. and Douglas G. Mose, 1972, Chronology of igneous events in the Precambrian of the St. Francois Mountains, southeast Missouri (abs.): Geol. Soc. America, Abstracts with Programs, v. 4, n. 7, p. 451-452.

Comparison of new U/Pb ages with previously published whole rock Rb/Sr ages indicated that the latter are consistently lower, by as much as 13%. It is concluded that the age of most of the rocks is about 1,500 m.y., but a 1,300 m.y. event is recorded in the Rb/Sr system.

Bickford, M. E. and A. L. Odom, 1968, Rb-Sr geochronology of igneous events in the Precambrian of the St. Francois Mountains, southeastern Missouri (abs.): Geol. Soc. America, program 1968 Ann. Mtg., p. 27.

Whole-rock Rb/Sr isochrons indicate that the Silvermine and Butler Hill granites are older (1,400 to 1,450 m.y.) than the Stouts Creek rhyolite ( $1,315 \pm 35$  m.y.) and the Munger granite porphyry and the Magee (Breadtray) granite ( $1,260 \pm 30$  m.y.). The "St. Francis (sic) Igneous Event" (1,270 to 1,430 m.y.) of Muehlberger, et al. (1966) thus consists of at least two distinct episodes.

Bickford, M. E. and W. R. Van Schmus, 1973, Possible Middle and Late Precambrian igneous arcs in the Mid-Continent region of North America (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 4, p. 300.

1.3 to 1.5 b.y. old silicic volcanic and shallow plutonic rocks in buried and exposed basement of Mid-Continent region considered as igneous arcs on the edge of older "proto-North American" continent; may be related to magmatic processes at convergent plate boundaries. Careful studies are needed (rock type distribution, major and minor element variations, isotopic ages) to demonstrate the operation of plate tectonic processes during Precambrian time.

Bissada, Kadry K., 1965, Interpretation of aeromagnetic data from southwest Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Includes Greenfield, Ash Grove, Fairplay, Stockton, Stockton 1, and Stockton 2 15-min. quadrangles. Major basement faulting is delineated from the magnetic maps; a large graben is indicated bounded by the Chesapeake fault zone to the SW and by the Eldorado Springs-Fairplay fault zone to the NE. Locally the emplacement of dike-like intrusive bodies is indicated along zones of intrabasement faulting; a large horseshoe-shaped composite high is interpreted as a ring-dike complex. Basement faulting is thought to have controlled the development of structures in the sediments. - M.G.S. manuscript file.

Buder, Theodore A., 1960, The geology of the northwest portion of the Lesterville Quadrangle, Reynolds County, Missouri: Unpubl. Master's thesis, Univ. Missouri-Columbia, Missouri.

Three small Precambrian knobs are mapped within the area; "normal" porphyritic rhyolite and "basic" porphyritic rhyolite are distinguished. The alignment of outcrops in the area suggests the rugged NE shoreline of an ancient sedimentary basin. The igneous knobs are overlain by Derby-Doerun dolomite. - M.G.S. manuscript file.

Callahan, W. H. and H. V. McMurry, 1970, Geophysical exploration of Mississippi Valley-Appalachian type strata-bound zinc-lead deposits in Mining and groundwater geophysics-1967, L. W. Morley, Ed.: Geol. Survey of Canada, Econ. Geol. Rept. No. 26, p. 350-360.

Refers to the influence of basement topography and structure on magnetic data in southeast Missouri (p. 358-359), concluding that magnetic surveys are not helpful in detecting buried igneous knobs and the Lamotte pinchout zone in the area. - M.G.S. library.

Chamon, Nagib, 1964, Structural and magnetic characteristics of the Belton anomaly, Cass County, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Chandiok, Kailash C., 1950, A detailed gravimetric survey of an area immediately south and east of St. Charles, Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

Corbitt, Lonnie L., 1966, Structural and modal analysis of the Butler Hill granite, southeastern Missouri: Unpubl. Masters thesis, Southern Illinois Univ., Carbondale, Illinois.

Not available for review.

Cullison, J. S. and S. P. Ellison, 1944, Diamond drill core from Bourbon high, Crawford County, Missouri: A.A.P.G. Bull. vol. 28, pt. 2, p. 1386-1396.

Petrographic description and log of U. S. Bur. Mines DDH #1. Precambrian rhyolite with disseminated magnetite and hematite and magnetite veins is indicated from 1,482 to 1,824 (TD) feet.

Davis, G. L., G. R. Tilton, L. T. Aldrich and G. W. Wetherill, 1958, The age of rocks and minerals: Ann. Rept. Geophys. Lab., Carnegie Inst. Washington, Yearbook 57, p. 176-181.

Not available for review. Mineral ages from Decaturville and Fredericktown, Mo., are included in this report.



Davis, James Wilson, 1969a, Petrogenesis and structure of the Knoblick granite: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Emplacement of the Knoblick granite (petrographically an adamellite) was accompanied by structural deformation and assimilation of the intruded volcanics. Trace and major element variations were determined by spectrochemical analysis. These variations are due primarily to chemical differentiation within the magma and to a lesser extent assimilation. Crystallization progressed from the NE toward the south-central portion of the intrusive. It is concluded that quantitative trace element studies can be used to correlate Missouri granites. - M.G.S. manuscript file.

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\_\_\_\_\_, 1969b, Petrogenesis and structure of the Knoblick granite in the Saint Francois Mountains, Missouri (abs.): Mo. Acad. Science Trans., v. 3, p. 104-105.

Published abstract of thesis (Davis, 1969a).

Denison, Rodger E., 1966, Basement rocks in adjoining parts of Oklahoma, Kansas, Missouri, and Arkansas: Unpubl. Doctoral dissertation, Univ. of Texas, Austin, Texas.

Petrographic description of basement samples from 14 drill holes in SW Missouri and some age determinations are included in this report. The following basement rock terranes, defined chiefly from samples in Kansas and Oklahoma, extend into Missouri: "Older granite and gneiss", Chase County granite group, Washington County volcanic group, Spavinaw granite group, Woodson County granite, and Vernon County metamorphic group. The Spavinaw Arch and the Vernon Syncline are basement structures extending into Missouri. - M.G.S. manuscript file.

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\_\_\_\_\_, 1968, Basement rocks in northeast Oklahoma (abs.): Geol. Soc. America, Spec. Paper 115, p. 368.

Volcanic rocks, microgranite, and micrographic granite from drill holes in NE Oklahoma and SW Missouri are interpreted as a volcanic epizone-type petrographic province, similar in many respects to the silicic part of the Cambrian Wichita province in southern Oklahoma. Isotope ages fall within the range of 1,130 to 1,280 m.y.

Denison, Rodger E., E. A. Hetherington, Jr., and J. B. Otto, 1969, Age of basement rocks in northeastern Oklahoma: Oklahoma Geology Notes, v. 29, n. 5, p. 120-128.

Microgranite core from McDonald County, Missouri, was dated  $1,216 \pm 30$  m.y. old by the Rb/Sr (whole rock) method.

Desborough, George A., 1963a, Mobilization of iron by alteration of magnetite-ulvospinel in basic rocks in Missouri: *Econ. Geology*, v. 58, p. 332-346.

Alteration of magnetite-ulvospinel to sphene-leucoxene in gabbros of Missouri involves significant mobilization of iron and causes mineralogic and chemical changes in the rocks that affects their density, magnetic susceptibility and thermo-remanent magnetic properties. High-temperature hydrothermal solutions were probably responsible for alteration of the basic rocks. Large scale mobilization of iron as a consequence of the alteration provides a possible source for certain non-titaniferous, high-temperature iron deposits associated with diabase.

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\_\_\_\_\_, 1963b, Magmatic sphalerite in Missouri basic rocks: *Econ. Geology*, v. 58, p. 971-977.

Sphalerite occurs as a minor constituent in fresh Precambrian olivine diabases and gabbros in southeast Missouri. Due to its optical properties and small grain size it is easily overlooked in the study of polished surfaces and thin sections. Textural relations and associated minerals indicate it is of magmatic origin.

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\_\_\_\_\_, 1967, Closed system differentiation of sulfides in olivine diabase, Missouri: *Econ. Geology*, v. 62, n. 5, p. 595-613.

Basic intrusives from drill core (Shepherd Mtn., 294-foot section) and outcrop (160-foot sill) were studied by universal stage, XRF, microprobe, and other methods. Extreme in-situ fractionation of olivine diabase to ferrogabbro observed in these two intrusives is unusual in other olivine diabases of comparable small size. The fractionation trends of the Missouri intrusives are compared to those of the Skaergaard intrusion of East Greenland. The paragenesis and abundance of primary sulfides (pyrrhotite, chalcopyrite, sphalerite, cubanite, pentlandite, and galena) are directly related to the differentiation parameters shown by the silicates. This and other studies seem to indicate that the separation and segregation of immiscible sulfides from basaltic magma is not an important process in the formation of economically significant Ni, Cu, and Zn ores that are associated with mafic or ultramafic rocks.

Desborough, George A. and Dewey H. Amos, 1961, Ilvaite: a late magmatic occurrence in gabbro of Missouri: *American Mineralogist*, v. 46, p. 1509-1511.

Ilvaite is identified by means of X-ray powder patterns and polished sections in unaltered gabbros of southeast Missouri. It is most abundant in samples without olivine, is associated with pyrrhotite, ilmenite, and magnetite, and was the last magmatic mineral to crystallize.



Douthit, Thomas D. N., 1959, Magnetic survey of the Cap au Gres faulted flexure: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

Ehrlich, Marvin I., 1966, Paleomagnetic and rock magnetic investigation of subsurface ore, host-rock, and basic dike specimens from the Precambrian Iron Mountain deposit, southeast Missouri: Unpubl. Doctoral dissertation, Washington Univ., St. Louis, Missouri.

Not available for review.

Ehrlich, Marvin I., S. Sun, L. H. Scharon and H. C. Soffel, 1969, Magnetic and paleomagnetic investigations of the Precambrian Iron Mountain deposits, southeast Missouri: Inst. Min. and Met. Trans., Bull. 753, v. 78, p. 114-122.

Not available for review.

Emery, John A., 1968, Geology of the Pea Ridge iron ore body in Ore deposits of the United States, 1933-1967, v. 1, John D. Ridge, Ed.: Am. Inst. Min., Met. and Petroleum Eng., p. 359-369.

The Pea Ridge iron ore deposit is described as a dike-like mass of magnetite enclosed in Precambrian porphyries. Five zones are distinguished within the ore body: magnetite, specular-hematite, porphyry-breccia, quartz-amphibole, and quartz-hematite. Associated minerals include apatite, fluorite, barite, calcite, and pyrite. The deposit is interpreted as a single injection of a magmatic differentiate with hydrothermal end phases forming the quartz-amphibole and quartz-hematite zones.

Erwin, Clarence Patrick, 1968, Interpretation of aeromagnetic data from central Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Includes Eugene, Meta, Iberia, Tavern, and Richland 15-min. quadrangles. Postulates a large anomalous mass at about one half mile below the basement surface; it is a crustal feature, extending to several miles in depth; a number of smaller anomalies are caused by intrusions to the basement surface from the underlying mass; a major NW-SE fracture system and a secondary NE-SW system in the basement control emplacement of source bodies. - M.G.S. manuscript file.

Fisher, Henry H., 1969, Stratigraphy and correlation of Precambrian volcanic rocks, Eminence, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Three small igneous knobs, including Coot Mountain, are mapped in detail in parts of the Eminence and Cardareva 15-min. quadrangles. Potash rhyolites, tuffs with devitrified glass shards and occasional ash balls are described. The Eminence area rhyolites are not considered to be ignimbrites.

Flawn, Peter T., Chairman, 1967, Basement map of North America between latitudes 24° and 60° N.: U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, scale 1:5,000,000.

Shows elevation of basement surface.

Flawn, Peter T. and William R. Muehlberger, 1970, The Precambrian of the United States of America: south-central United States in The Precambrian, v. 4, Kalervo Rankama, Ed.: Interscience Publishers, New York, p. 73-143.

Review article. Data on exposed Precambrian rocks are summarized on p. 118-127; basement rocks of Missouri are referred to on p. 136. The bibliography (p. 137-143) lists pertinent references to 1966. - M.G.S. library.

Fox, James H., 1954, "Cryptovolcanic" force fields: Unpubl. Doctoral dissertation, St. Louis Univ., St. Louis, Missouri.

Magnetic and gravity survey of the Crooked Creek disturbance. A magnetic map (vertical component), and Bouguer, residual, and second derivative gravity maps were prepared at a scale of 3" to 1 mi. The results indicate that the Crooked Creek disturbance was generated by intraterrestrial forces. The disturbance has a magnetically and gravimetrically "low" geophysical signature; shattering of the basement rocks is indicated. It occurs at the intersection of the Palmer and Cuba fault zones that are extended westward and southward, respectively, beyond the disturbance; the Cuba fault extension appears to be deep seated and regional in character. The source of an isolated magnetic high centered at station 165 is described as a magnetic dipole, with its upper pole at a depth of 2,400 feet beneath the surface. Concentrated magnetite stringers or a pipe-like intrusive of high susceptibility could account for this anomaly. The anomaly could be related to the mechanism active in the formation of the disturbance. The ring graben suggests a hinge type of downward movement. The deforming force was localized and vertically directed. Explosive action is indicated, but slow doming and collapse could have been contributory. There is no evidence that magmatic emplacement and/or subsidence played a major role. The structure can be explained through explosive release of magmatic gases initially derived from a deep seated source. The paper includes a discussion of the cryptovolcanic controversy, presents several possible theories of origin, and considers the Crooked Creek structure in its regional tectonic framework suggesting its possible relationship to the Decaturville structure and the Avon diatremes. - M.G.S. manuscript file.

Frohlich, Reinhard K., 1970, Gravity measurements near the Ozark uplift in Missouri: Unpubl. report of student project for course 383, Gravity and Magnetic Prospecting, Univ. Missouri-Rolla, Rolla, Missouri.

Results of a gravimetric profile on the north flank of the Salem gravity high (Dent County) are not conclusive enough to decide whether the anomaly is due to a basement high or density contrasts at greater depths. - M.G.S. manuscript file.

Gerlach, George S., 1959, A regional gravity survey of St. Francois Mountains of Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Not available for review.

Gillerman, Elliot, 1968, Major lineaments and possible calderas defined by side-looking airborne radar imagery, St. Francois Mountains, Missouri: Natl. Aeronautics and Space Admin; CRES Tech. Rept. 118-12, 29 p.

Linear structural features depicted on radar imagery represent faults or fractures. Most prominent among these is identified as the Roselle lineament that can be traced outside the limits of radar coverage by inference of structural and topographic features for 135 miles, and that may have a relationship to mineralization in the Bonne Terre-Fredericktown area. Circular patterns are identified SW of Marquand, Madison County, S of Annapolis, Iron County, S of Viburnum and W of Corridon, both in Reynolds County. Their origin is obscure but ancient astroblemes or calderas are suggested as a working hypothesis. - M.G.S. manuscript file.

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\_\_\_\_\_, 1969, The Roselle lineament of southeast Missouri (abs.): Geol. Soc. America, Abstracts with Programs for 1969, Part 2, South-Central Sec., p. 11-12.

Roselle fault is defined as part of the Roselle lineament. It is suggested that this lineament has been in existence since the Precambrian and is a major lineament of this portion of the crust.

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\_\_\_\_\_, 1970, Roselle lineament of southeast Missouri: Geol. Soc. America Bull., v. 81, n. 3, p. 975-982.

The Roselle fault and lineament are described in detail. Of the several shorter subparallel faults east of Roselle the most prominent one is named the Murphy Hill fault. Faulting was pre-Lamotte and probably Precambrian in age and resulted in a graben or half-graben valley. The Silvermine fault is shown to be offset by the Roselle fault. The alignment of topographic and structural features along the Roselle lineament is shown from N of St. Louis S-SW to the Mississippi Embayment. (The faults named in this paper were mapped by Amos and Desborough in 1958-62, but their map was not published until 1970. - Editor's note).

Green, John C., 1970, Snowflake texture not diagnostic of devitrified ash-flow tuffs: Discussion: Geol. Soc. America Bull., v. 81, n. 8, p. 2527-2528.

This paper questions the claim of Jay Earl Anderson (1970a) that large volumes of late Precambrian felsic volcanic rocks in Missouri are ash-flow tuffs. Many Keweenawan lava flows show snowflake texture in their interiors and it appears that such a texture has little bearing on the eruptive characteristics of a flow, but perhaps is the result of crystallization of any felsic glass.

Greenberg, S. S. and C. J. Vitaliano, 1962, Basalt from a deep well in Lawrence County, Indiana: Jour. Geology, v. 70, n. 4, p. 482-488.

On the basis of similarities in texture, mineralogy, and chemical composition altered basalt from Indiana is correlated with Keweenawan lava flows of Michigan and with basalt and diabase from the Skrainka quarry, Madison County, Missouri. It is suggested that all are of similar age.

Greene, F. C., 1925, Granite wells in the northern Midcontinent region: Amer. Assoc. Petroleum Geologists Bull., v. 9, p. 351-354.

Five basement drill holes from Missouri are included in the list.

Grenia, J. D., 1960, Precambrian topography and rock types: Unpubl. map, Mo. Geol. Survey and Water Resources, 1 sheet, scale approx. 1 in. to 24 mi.

Map of basement rock configuration and rock types.

Hamilton, Warren and Bradley Myers, 1967, St. Francois Mountains batholith in The nature of batholiths: U. S. Geol. Survey, Prof. Paper 554C, p. C12.

The plutonic rocks are inferred to have crystallized beneath the volcanic crust thickened by a rapidly crystallized roof facies of granophyre; the cover was probably not thicker than 3 km. Gravity surveys indicate that the Precambrian complex in the St. Francois Mountains is batholithic rather than lopolithic.

Hansink, James D., 1965, Geology of the Graniteville granite, Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

The distribution of major minerals within the northern intrusive body was determined by modal analysis of 100 thin sections; Na, K, and Fe distribution was determined by AAS. The granite is intrusive into Stouts Creek rhyolite with which it has a nearly vertical, sharp contact. The magma was probably emplaced as a relatively cool crystal hash by piece-meal stoping. Both iron and magnetite concentrations are at peaks in a NE trending anomaly in the southern portion of the outcrop. Late residual fluids may have been an influence on the formation of the iron deposits at Iron Mountain, 4 mi. NE of the study area. - M.G.S. manuscript file.

Hansink, James D. and Charles B. Belt, 1965, Geology of the Graniteville granite, Missouri (abs.): Geol. Soc. America, Special Paper 87, p. 72.

This paper is the abstract of the thesis by Hansink (1965).

Hayes, W. C., compiler, 1959a, Chemical analyses, Precambrian rocks of Missouri: Mo. Geol. Survey and Water Resources, Misc. Publ., 14 p.

List of 93 published and unpublished chemical analyses.

\_\_\_\_\_, 1959b, Geology and exploration of Missouri iron deposits: Mo. Geol. Survey and Water Resources, Misc. Publ., 16 p.

Precambrian magnetite and hematite deposits of Missouri are classified as hydrothermal. Brief descriptions of the Iron Mountain, Shepherd Mountain, and Pea Ridge deposits. Major magnetic anomalies in Missouri are shown and the status of Precambrian iron exploration in the state is summarized.

\_\_\_\_\_, 1961a, Precambrian rock units in Missouri in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 81-83.

The classification and nomenclature of Precambrian igneous rocks in southeast Missouri is presented.

\_\_\_\_\_, 1961b, Physiographic features of the St. Francois Mountains in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 115-118.

Drainage patterns and weathering characteristics of the exposed Precambrian rocks in Missouri are discussed with a list of shut-ins.

\_\_\_\_\_, 1962, Configuration of the Precambrian surface showing major structural lineaments: Unpubl. map, Mo. Geol. Survey and Water Resources, 1 sheet, scale 1:1,000,000.

Map shows area of Precambrian outcrops, location of drill holes, and contours drawn on the Precambrian surface at 200 and 1,000 feet intervals.

\_\_\_\_\_, 1967, Precambrian rocks of Missouri in Mineral and water resources of Missouri: Mo. Geol. Survey and Water Resources, v. 43, p. 15.

Summary of buried and exposed Precambrian rocks of the state. Buried Precambrian rocks are said to be similar to those exposed on the Canadian Shield and may be of the same general age, that is, early to middle Precambrian.

Hays, Walter W., 1961, A paleomagnetic investigation of some of the Precambrian igneous rocks of southeast Missouri: Unpubl. Doctoral dissertation, Washington Univ., St. Louis, Missouri.

Magnetic susceptibility and remanent magnetization measurements of 250 felsite, diabase, and granite samples from the Ironton, Fredericktown and Coldwater 15-min. quadrangles indicate that the directions of remanent magnetization are significantly different from the direction of the present geomagnetic field in southeast Missouri. Similar mean directions of remanent magnetization for the Stouts Creek, Hogan Mountain, and Royal Gorge rhyolites suggest that these rock units are contemporaneous and possibly genetically related. The Iron Mountain andesite and the Skrainka diabase are probably also related to the rhyolites and the formation of all five rock units probably represents a relatively short interval of Precambrian time. - M.G.S. manuscript file.

Hays, Walter W. and LeRoy Scharon, 1963, An example of the influence of remanent magnetization on magnetic intensity measurements: *Geophysics*, v. 28, p. 1032-1043.

Not available for review. May be pertinent to Boss-Bixby anomaly.

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\_\_\_\_\_, 1966, A paleomagnetic investigation of some of the Precambrian igneous rocks of Missouri: *Jour. Geophys. Research*, v. 71, n. 2, p. 553-560.

This article is a concise report of the results obtained by Hays (1961). - M.G.S. reprint file.

Heinrich, R. R., 1955, Earthquakes and structural trends in the central stable region of the North American continent, Pt. 1, Regional considerations; Pt. 2, The New Madrid area, Missouri: *Earthquake Notes*, v. 26, p. 7-8, and p. 16-20.

Not available for review.

Henderson, R. G. and I. Zietz, 1958, Magnetic-doublet theory in the analysis of total intensity anomalies: *U. S. Geol. Survey Bull.* 1052-D, p. 159-186.

Discussion of typical magnetic-doublet profiles and their use in the interpretation of aeromagnetic maps. Calculated depth of source on a closed magnetic high in the Coldwater 15-min quadrangle in southeast Missouri is in satisfactory agreement with the flight elevation over the exposed felsite (p. 179-180). For satisfactory results the effective radius of the disturbing body must be less than its depth of burial.

Heyl, Allen V., 1967, The 38th parallel lineament and its relationship to ore deposits (abs.): *Min. Eng.*, v. 19, n. 12, p. 33.



\_\_\_\_\_, 1972, The 38th parallel lineament and its relationship to ore deposits: *Econ. Geology*, v. 67, p. 879-894.

Description of structural features along the 38th parallel lineament marked by nearly continuous segments of surface faults, mafic alkalic igneous dikes, breccias and pipes of different ages, and stratigraphic changes. The near-surface features probably overlie a right-lateral wrench-fault zone in the Precambrian basement. Westward extension of the lineament across central Missouri into Kansas is marked by crypto-explosion structures and ultramafic intrusions; continuation into Colorado (Rocky Mountain front) is suggested. The lineament is postulated to be the continental equivalent of the great oceanic fracture zones, such as the Mendocino and the Kelvin.

Hill, T. E., Jr., H. Kenworthy, R. A. Ritchey and J. A. Gerard (1969), Separation of feldspar, quartz and mica from granite: U. S. Bur. Mines, Rept. Inv. 7245, 25 p.

Describes the recovery of usable feldspar and quartz from Graniteville granite. Includes petrographic descriptions and chemical analysis.

Howe, Wallace B., Vincent E. Kirtz and Kenneth H. Anderson, 1972, Correlation of Cambrian strata of the Ozark and Upper Mississippi Valley regions: *Mo. Geol. Survey and Water Resources*, Rept. Inv. 52, 68 p.

This report includes four drill holes in Missouri that bottomed in basement rocks.

Hsu, I-Chi, 1962, Paleomagnetic investigations of some of the Precambrian volcanic rocks in the St. Francois Mountains, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

This investigation covers the area of volcanics mapped by Anderson (1962). Remanent magnetization measurements were made on 70 samples, including 11 from drill cores. The origin and properties of remanent magnetization are controlled by degree of devitrification; chemical magnetization is considered to be the most important factor; the most stable component is believed to be thermoremanent magnetization. The geomagnetic field was stable throughout this epoch of Precambrian igneous activity. The mean pole position of all the samples is calculated to be in the vicinity of 147° W, 50°30' N. - M.G.S. manuscript file.

Hsu, I-Chi, R. E. Anderson and LeRoy Scharon, 1966, Paleomagnetic properties of some Precambrian rocks in Missouri: *Jour. Geophys. Research*, v. 71, n. 10, p. 2645-2650.

Not available for review.

International Geophysical Year Bulletin No. 34, 1960, Seismic crustal studies during the I.G.Y., pt. 2, Continental program: Am. Geophysical Union Trans., v. 41, p. 351-355.

Not available for review. Includes measurements of crustal structure in the buried shield area near the head of the Mississippi embayment in Arkansas and Missouri.

Iowa Geological Survey, 1973, Preliminary interpretation report--Airborne magnetometer survey of southern Iowa (adapted from Report of airborne magnetometer survey by Lockwood, Kessler and Bartlett, Inc.): Iowa Geol. Survey, 17 p., 2 maps, scale 1:500,000, contour interval 20 and 100 gammas.

Survey covers area south of latitude 40°54' N. along the Iowa-Missouri border. "Deep" basement areas are inferred that exceed those shown on Basement rock map of the United States (Bayley and Muehlberger, 1968), and where basement elevations may well exceed -5,000 feet. "Shallow" igneous rock overlies the crystalline basement in certain areas and these type anomalies may not necessarily reflect "basement" anomalies.

Johnson, Clayton H., 1961, A brief description of Pilot Knob in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 127-128.

Describes the stratigraphic relationships and iron mineralization at Pilot Knob. The presence of a thin layer of clay between rhyolite and overlying tuffs indicate that the latter are sedimentary.

Kailasam, Lakshmi N., 1953, Geophysical investigations of a near-surface geologic structure in the neighborhood of Saint Charles, Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

Kisslinger, Carl and Otto W. Nuttli, 1965, The earthquake of October 21, 1965 and Precambrian structure in Missouri: Earthquake notes, v. 36, p. 32-36.

Intensity data from the earthquake show a clear connection to the major Precambrian structure in the central part of the state. The areas of perceptibility and damage are shifted to the NW relative to the epicenter, along a major structural lineament. The instrumental epicenter falls near the Black fault in Reynolds County. - M.G.S. reprint file No. 744.



Kisvarsanyi, Eva B., 1960, Comparative petrographic, petrochemical, and spectrographic analyses of the Precambrian granitic rocks of southeastern Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Exposed and some subsurface granite types are described on the basis petrographic analysis of 44 thin sections, 27 chemical analyses (Niggli classification), and semi-quantitative spectrochemical analysis of 44 samples. The rocks are classified as calc-alkaline with high silica and alkalies, and low lime contents. - M.G.S. manuscript file.

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\_\_\_\_\_, 1961, Spectroscopic distribution of the trace elements in the Precambrian granites of southeastern Missouri in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 95-105.

Report on semi-quantitative spectrographic analysis of 44 granite samples. Index trace elements (Mg, V, Cr, Co, B, Zn, Sn, Pb) are used to distinguish between various granite types by means of "rose" diagrams. Comparison with granites from other areas shows that the Missouri granites have a high frequency distribution of Cu, Mo, Zn, Pb, Sn, and B.

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\_\_\_\_\_, 1966, Occurrence of alkali syenite in the vicinity of Johnson Shut-ins State Park, Missouri: Missouri Mineral Industry News, v. 6, n. 11, p. 109-111.

Petrographic description. Coarse trachytoid texture and absence of quartz and plagioclase characterize the rock. Altered mafic minerals were probably biotite and riebeckite. Primary apatite and late replacement hematite are common.

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\_\_\_\_\_, 1972, Petrochemistry of a Precambrian igneous province, St. Francois Mountains, Missouri (Contribution to Precambrian Geology No. 4): Mo. Geol. Survey and Water Resources, Rept. Inv. 51, 103 p.

65 chemical analyses, representing most of the exposed Precambrian rock units, are classified by the Niggli method. Variation and QLM diagrams show that the igneous province is calc-alkalic with strong alkalic affinities in the high silica members; the latter are comparable to world averages of alkali granites and alkali rhyolites. Observed deviations from normal calc-alkalic trends may be due to contamination of source magmas by assimilation of sialic material, or due to post-magmatic processes. Appendix lists 91 chemical analyses.

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\_\_\_\_\_, 1973, Precambrian rocks in the subsurface of Missouri (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 4, p. 326-327.

On the basis of data from 550 basement wells 5 major Precambrian rock types are distinguished: 1, "older" gneissic granite and schist, 2, basic plutonic association of gabbro, norite and diorite, 3, subsurface extension of the St. Francois Terrane, 4, tholeiitic olivine basalt association, and 5, unmetamorphosed clastic sediments.

Kisvarsanyi, Geza, 1966, Geochemical and petrological study of the Precambrian iron metallogenic province of southeast Missouri: Unpubl. Doctoral dissertation, Univ. Missouri-Rolla, Rolla, Missouri.

Petrologic and geochemical relationships between ores and host rocks in the Iron Mountain, Pilot Knob, Pea Ridge, Bourbon, Shephard Mountain, Cedar Hill, and Boss-Bixby deposits are established on the basis of quantitative spectrographic analysis of 83 purified magnetite, hematite, bulk ore and 34 rock samples; 45 polished sections, 20 thin sections, and 19 X-ray analyses of minerals. A close correlation exists between rock types and trace element populations. Intermediate rocks, rich in Cr, V, Mn, Ni, Cu, and Zn, appear genetically linked with the major iron deposits in the province. The iron deposits are considered to be products of differentiation and liquid immiscibility of magmas, caused by fractional crystallization, incongruent melting of iron silicates, magmatic oxidation, and enrichment of magma in volatile constituents at the intermediate stage of differentiation. The temperature range of formation is estimated from 600° C to below the critical temperature of water. The chemistry of the iron rich phase and the amount of volatile constituents were important factors in determining the emplacement characteristics of individual deposits. The Pea Ridge, Iron Mountain, and Bourbon deposits are classified as ore magma injections with some hydrothermal phases; the Boss-Bixby deposit is transitional to igneous contact metasomatic deposits; Shephard Mountain and Cedar Hill display hydrothermal vein deposition; and Pilot Knob is of the hydrothermal replacement type. - M.G.S. manuscript file.

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\_\_\_\_\_, 1967a, Geochemical and petrological study of the Precambrian iron metallogenic province of southeast Missouri (abs): Dissert. Abs., Sec. B, Sci. and Eng., v. 27, n. 9, p. 3150B-3151B.

Published abstract of dissertation (Kisvarsanyi, G., 1966).

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\_\_\_\_\_, 1967b, Problems in the genesis of non-titaniferous apatitic iron deposits (abs.): Missouri Acad. Sci. Trans., v. 1, p. 88-89.

Apatitic iron deposits of the Kiruna type occur in the Precambrian iron metallogenic province of southeast Missouri. These type deposits are derived from ore magmas composed mainly of iron oxide-apatite with variable amounts of volatiles (composition of a surface volcanic flow in Chile, geometric form of forceful intrusion, fluidal or poikilitic texture of igneous minerals, contact metamorphic aureole). Endogene processes (differentiation and liquid immiscibility) are the probable cause of ore magma formations. Alkaline and subalkaline petrographic provinces show enrichment of alkali metals, iron, and volatiles at the intermediate stage of differentiation. Experimental evidence offers a basis for extrapolation that this process is operative in natural environments; the source is generally a magma of intermediate composition. The bulk of primary minerals in these type deposits crystallized at higher than hydrothermal temperatures; high temperature spinels (magnesioferrite, Zn-Fe spinel) in the Missouri deposits, lack of alteration halos, presence of pyroxene-amphibole-feldspar and garnet

skarns are indications of high temperatures in the crystallizing body. Local hydrothermal minerals within or near the margins of these ore bodies are generally later than the main body. Oxidation of magma is probably through the oxides of H and N. Trace element geochemistry of Missouri deposits is similar to that of magmatic injection deposits elsewhere; internal elemental zoning of ore bodies is in accord with the mineralogical zoning.

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, 1973, Geologic sequence of igneous activity in the Precambrian St. Francois Terrane, Missouri (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 4, p. 327.

Sequence of magmatic periods is defined as follows: regional high silica volcanism accompanied by epizonal plutonism; structurally controlled emplacement of intermediate magmas; injection of ore magmas locally with hydrothermal fluids; emplacement of second generation granite, pegmatite and aplite; intrusion of basic magmas. Cauldron subsidence and ring dike emplacement characterize consolidation of the first period. Metasomatism, assimilation, hybridization, contact metamorphism, and mineralization accompanied the later periods. Locally biotite schist formed by dislocation metamorphism of andesite dikes.

Kisvarsanyi, Geza, and Paul D. Proctor, 1967, Trace element content of magnetites and hematites, southeast Missouri iron metallogenic province, U.S.A.: Econ. Geology, v. 62, n. 4, p. 449-471.

Describes geologic setting and trace element geochemistry of Missouri's Precambrian iron deposits. Trace element contents decrease toward the margins of ore bodies; high and low electronegativity pairs (V/Zn, V/Cu, Mg/Co) show the same pattern and suggest temperature control of trace element concentration. Ti/V ratios and V content of purified magnetites are comparable to those of magmatic injection deposits of the world. Geochemical and geologic character of the ore bodies suggest that ore magma injection, contact metasomatism, and hydrothermal replacement were the most important ore forming processes in this metallogenic province.

Ku, Chao-Cheng, 1965, Paleomagnetic investigations of some of the Precambrian rocks in the St. Francois Mountains, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Not available for review.

Kurtz, Vincent E., Joseph L. Thacker, Kenneth H. Anderson and Paul E. Gerdemann, 1973, Traverse in Late Cambrian strata from the St. Francois Mountains, Missouri to Delaware County, Oklahoma (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 4, p. 329-330.

Several drill cores in south-central Missouri that bottomed in basement rocks are included in this study. The thickest Cambrian section, in Douglas County, reflects negative tectonism; a south-facing embayment is postulated.

Laing, E. M., 1963, The relationship between surface geologic structure and aeromagnetic anomalies in east-central Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Not available for review.

Leaf, Howard L., 1955, A magnetometer survey of the magnetic highs to the east of St. Clair, Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

Lemmon, Robert D., 1964a, Petrographic and modal analysis of the Slabtown granite, southeast Missouri: Unpubl. Masters thesis, Southern Illinois Univ., Carbondale, Illinois.

56 samples of Slabtown granite were taken on  $\frac{1}{2}$  mile grid spacing and the areal distribution of the granite was mapped utilizing aerial photographs. The granite is classified as a fine grained, homogeneous, hornblende granite, characterized by granophyric texture; it is a moderately shallow, magmatic emplacement representing a single rock phase; it may be a sill-like body that dips moderately to the SE. Post-consolidation stress from the SW produced two major joint sets; the NE set is genetically related to dikes and faults in the area. - M.G.S. manuscript file.

Lemmon, Robert D., 1964b, Distribution and composition of the Slabtown granite, southeast Missouri (abs.): Missouri Acad. Science Proceedings, v. 1, ser. 2, p. 35.

Published abstract of thesis.

Leney, George W., 1964, Geophysical exploration for iron ore: Am Inst. Min., Met., and Petroleum Eng. (S.M.E.) Trans. v. 229, p. 355-372.

Includes discussions of the aeromagnetic anomaly at Pea Ridge, and ground magnetic, gravity, and electrical surveys at Iron Mountain.

\_\_\_\_\_, 1966, Field studies in iron ore geophysics in Mining Geophysics, v. 1, Case Histories: Tulsa, Oklahoma, Soc. Explor. Geophysicists, p. 391-417.

Discusses the feasibility of geophysical exploration methods in the search for iron ore. References to the discoveries of Pea Ridge and the underground ore body at Iron Mountain. - M.G.S. library.

Lidiak, E. G. and R. E. Denison, compilers, 1963, Annotated bibliography of basement rocks of North America, App. A: Unpubl. manuscript, An Investigation of the buried crust of North America, Quart. Progress Rept. for the period 1/1/63 to 3/1/63, Univ. Texas, Austin, Texas.

Contains 234 individual entries pertaining to basement rocks of North America, including several to Missouri. - M.G.S. manuscript file.

Lin, Jia-Wen, 1971, Gravity and magnetic study, central Ozark uplift, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Study covers an area bounded by  $36^{\circ}30'$  and  $38^{\circ}$  N. latitude, and  $91^{\circ}$  and  $92^{\circ}$  W. longitude in southeast Missouri, in the region where the St. Francois Dome and the Van Buren Arch elements of TIKRITY (1968) separate. Low density granite of batholithic dimensions underlies the whole thesis area; zone of crustal weakness may have been the hinge zone for the general SE tilt of the southern part of the area; basic rock bodies are localized along the line of crustal weakness; the proposed batholithic model consists of a roof region with relatively flat dip and walls with fairly steep outward dips, typical of post-kinematic batholiths. - M.G.S. manuscript file.

Lowell, Gary R. and J. Ronald Sides, 1973, The occurrence and origin of rapakivi granite in the St. Francois Mountains batholith of southeast Missouri (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 4, p. 332-333.

Local development of rapakivi texture within the Butler Hill granite is described. Its association with aplite dikes suggests structural control by late-stage fracturing, permitting volatiles to escape from the crystallizing magma.

McCracken, Mary H., 1971, Structural features of Missouri: Mo. Geol. Survey and Water Resources, Rept. Inv. 49, 99 p.

This list of more than 450 named and described structures in Missouri accompanies a map (scale 1:500,000) of known structural features, and includes several Precambrian structures. The material is indexed alphabetically and by county; list of references.

McDaniel, Alice Carol, 1969, An optical study of the minerals in iron deposit at Pilot Knob, Missouri: Rocks and Minerals, v. 43, n. 10, p. 723-728.

Malan, Roger C., 1972, Analytical data, Precambrian igneous rocks, St. Francois Mountains: Unpubl. rept., U.S. Atomic Energy Comm., Grand Junction, Colorado.

Emission spectrographic determination of major and minor elements in 44 samples; atomic absorption analysis of copper in 44 samples; gamma ray spectroscopic determination of U, Th, and K in 72 samples. - M.G.S. manuscript file.

Mantei, Erwin J., 1962,  $K_2O/Na_2O$  content as a possible index to the chronological sequence of some Precambrian igneous rocks of Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Results of flame photometric analysis for  $K_2O$  and  $Na_2O$  on 31 samples of Precambrian igneous rocks from outcrops in southeast Missouri indicate that the Middlebrook volcanics belong to a separate magmatic cycle; that the Van East, Musco, and Bevos groups belong to the same magmatic cycle; and that the basic intrusive rocks belong to a separate magmatic cycle. A chronological sequence is suggested for the named units based on the systematic variation of  $K_2O/Na_2O$  ratios within a differentiating magma. - M.G.S. manuscript file.



\_\_\_\_\_, 1964,  $K_2O/Na_2O$  content as a possible index to the chronological sequence of some Precambrian igneous rocks of Missouri (abs.): Missouri Acad. Science Proceedings, v. 1, ser. 2, p. 35-36.

Published abstract of thesis (Mantei, 1962).

Mateker, Emil J., Jr., 1959, Some gravity and magnetic interpretation problems in eastern Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

\_\_\_\_\_, 1968, Geologic information from geophysical anomalies in the central stable region (abs.): Geol. Soc. America, program 1968 Ann. Mtg., North-Central Sec., p. 33.

Limitations and problems involved in the interpretation of geophysical data are illustrated by consideration of magnetic and gravity data along the eastern flank of the Ozark Uplift.

Mateker, Emil J., M. J. Phelan and LeRoy Scharon, 1966, Geophysical evidence for a northeast-trending crustal lineament near St. Louis (abs.): Missouri Acad. Sci. Proceedings, v. 3, ser. 2, p. 63.

A broad, large amplitude gravity anomaly appears to have a source several thousand feet below the top of the basement, and a magnetic anomaly associated with it. It is suggested that the region may be a major Precambrian graben into which basic material was intruded. Gravity and magnetic data of the Wentzville anomaly (St. Charles County) indicate that basic material extends to great depth.

Merriam, D. F., V. B. Cole and W. W. Hambleton, 1962, Precambrian basement rock types in Mid-continent region (abs.): Am. Assoc. Petroleum Geologists Bull., v. 46, p. 272.

Reference to a wide band of metasediments through central Missouri, NE Kansas, NE Nebraska, and SE South Dakota. It is assumed to outline the SW flank of the old Wisconsin Highlands. In many areas deeply weathered and perhaps even reworked pre-Reagan (or Lamotte) basement rock constitutes "Granite-wash", assumed to be Precambrian.

Meyerhoff, Howard A., 1970, Basement relief beneath the Upper Cambrian of the Mid-continent (abs.): Geol. Soc. America, Abstracts with Programs, v. 2, n. 6, p. 396.

Where well control and/or geophysical data are available, basement relief ranging from 600 to 2,500 feet has been found consistently from Wisconsin south to the St. Francois Mountains and west to Texas. Dating of igneous rocks of the Wichita Mountains as early Cambrian suggests a tectonic-plutonic event of major proportion and possible regional extent, the effects of which were still pronounced when late Cambrian transgression occurred. The implications of high relief warrant a more definitive study and analysis of pre-Upper Cambrian topography.

Missouri Geological Survey and Water Resources, 1943, Gravimetric map of Missouri: 1 sheet, contour interval 50 milligals, scale 1:500,000.

A Bouguer anomaly map compiled from gravimeter surveys; observations were taken along the main highways.

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\_\_\_\_\_, 1943, Magnetic map of Missouri showing anomalies of vertical intensity: 1 sheet, contour interval 100 gammas, scale 1:500,000.

A map compiled from detailed magnetometer surveys; observations were taken at one mile intervals.

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\_\_\_\_\_, 1961 to 1967, Aeromagnetic quadrangle maps showing anomalies of total intensity: 89 sheets, contour interval 10 and 50 gammas, scale 1:62,500.

See Index Map of published aeromagnetic maps, July, 1971.

Missouri Mineral Industry News, 1968, Missouri Geological Survey initiates Operation Basement: V. 8, n. 11, p. 113-114.

Announcement of a Survey program to 1, establish a Precambrian sample library, 2, expand Precambrian studies, and 3, publish the results in a series entitled "Contributions to the Precambrian Geology of Missouri".

Mitchell, Gary Clark, 1971, Gravity survey and crustal structure of east-central Missouri: Unpubl. Masters thesis, Univ. Missouri-Columbia, Columbia, Missouri.

Area of investigation includes New Florence, Warrenton, Troy, Hermann, Washington, Augusta, Gerald, Union, and St. Clair 15-min. quadrangles. Bouguer anomaly map shows 4 well defined circular gravity highs, two small circular lows, and an area of steepened gradient. These reflect structural and lithologic changes in the Precambrian basement. The steep gravity gradient is postulated to be associated with vertical basement faulting with no surface expression. - M.G.S. manuscript file.

Mose, Douglas G., 1971, Chronology of Precambrian volcanic rock units in the center of the St. Francois Mountains, Missouri: Unpubl. Doctoral dissertation, Univ. of Kansas, Lawrence, Kansas.

Area of investigation covers parts of Graniteville, Iron Mtn. Lake, Ironton, and Lake Killarney 7½-min. quadrangles. The Rb/Sr isotope composition of approximately 100 samples of Stouts Creek rhyolite, Brown Mtn. rhyolite, and other volcanic rock units was determined. Age determinations indicate that the extrusive rocks are all the same age at the 95% confidence level, or about 1,350 m.y. old. Discusses various processes that can lower whole-rock ages; ages obtained in this study should be regarded as minimum ages, dependent upon the amount of Sr mobilization. - M.G.S. manuscript file.

Mose, Douglas G. and M. E. Bickford, 1972a, Chronology of Precambrian volcanic rock units in the center of the St. Francois Mountains, Missouri (abs.): Internat'l. Geol. Congress, Abstracts for 24th Session, Montreal, p. 18.

Abstract of paper presented at the Congress.

\_\_\_\_\_, 1972b, Chronology of Precambrian volcanic rock units in the central St. Francois Mountains, Missouri in Sec. 1, Precambrian Geology: 24th Internat'l. Geol. Congress, Montreal, p. 230-237.

Field and petrographic studies of the volcanic rocks do not reveal the sequence of extrusive events. Whole-rock Rb/Sr age determinations indicate that all units were emplaced about 1,350 m.y. ago. Analytical errors associated with the Rb/Sr method were found to be larger than previously estimated; the errors may result from failure of the rocks to remain as closed chemical systems.

Moss, R. G., 1936, Buried Precambrian surface in the United States: Geol. Soc. America Bull., v. 47, p. 935-966.

The configuration and major structural features of the buried Precambrian surface are discussed and illustrated by a series of maps. The Ozark uplift is recognized as an old structural feature and the Lincoln anticline and the Cap au Gres fault are considered as part of the uplift. Many of the present major surface structures have been largely influenced and guided by earlier lines of deformation in the Precambrian basement.

Muehlberger, William R., Carl E. Hedge, Rodger E. Denison and Richard F. Marvin, 1966, Geochronology of the Midcontinent region, United States; 3. Southern area: Jour. Geophys. Research, v. 71, n. 22, p. 5409-5426.

Isotope ages of 18 basement samples from Missouri are listed. These suggest that a good part of the Precambrian basement of Missouri is 1,500 m.y. or more in age. The St. Francois igneous activity denotes a magmatic period in southeast Missouri 1,200 to 1,350 m.y. ago. Essentially continuous igneous activity during Late Precambrian time is recorded by basement rocks of the southern Midcontinent. - M.G.S. reprint file.

Muehlberger, William R., Rodger E. Denison and Edward G. Lidiak, 1967, Basement rocks in continental interior of United States: Am. Assoc. Petroleum Geologists Bull., v. 51, n. 12, p. 2351-2380.

Discusses and illustrates the Precambrian evolution of central North America based on numerous drill hole data and previous petrographic and geochronologic studies. Late Precambrian rhyolite-granite complexes are considered to form a band extending southwestward from western Ohio to eastern New Mexico. Preservation of these supracrustal and epizonal rocks suggests the top or nearly the top of the Precambrian crust is preserved along the belt.



Murphy, John E. and Victor M. Mejia, 1961, Underground geology at Iron Mountain in Guidebook to the geology of the St. Francois Mountain area: Missouri Geol. Survey and Water Resources, Rept. Inv. 26, p. 129-137.

Stratigraphic sequence of Precambrian rocks, from oldest to youngest, is described as follows: pyroclastics, southern rhyolite, dacite, northern rhyolite, mineralized andesite, felsite. The andesite is indicated to be an intrusive. The mineral composition and structure of the two ore bodies are described. The magmatic injection theory is favored for the genesis of the ore bodies. The source may have been the residual magma of a deep seated intrusive; scattered granite blocks in a post-ore andesitic dike underground suggest the nearness of an intrusive granite.

Murphy, John E. and Ernest L. Ohle, 1968, The Iron Mountain Mine, Iron Mountain, Missouri in Ore deposits of the United States, 1933-1967, Volume 1, John D. Ridge, Ed.: Am. Inst. Min., Met. and Petroleum Eng., p. 287-302.

Detailed description of the geologic setting, structure, and mineralogy of the deposits. The ore is said to be later than the andesite host rock, but earlier than the andesite dikes. In this paper the authors cite several supporting evidences for a hydrothermal origin of the ores besides those that suggest injection of an iron-rich melt and regard the genesis of the deposits unresolved.

O'Brien, Richard P., 1961, Exploratory drilling at Union Electric's Taum Sauk project in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 122-126.

Results of preliminary and secondary drilling programs are discussed. "During the overburden stripping operations in the upper reservoir area the contact between the rhyolite porphyry and the granite porphyry was uncovered. Evidence was found that clearly indicated that the rhyolite had flowed out on the weathered surface of the granite, scorching and baking it. This indicates that at least at this location the granite porphyry is older than the rhyolite porphyry and is not intrusive into it contrary to some earlier speculations on this question."

Offield, Terry W., Howard A. Pohn and Charles W. Naeser, 1970, The character and origin of the Decaturville, Missouri, cryptoexplosion structure (abs.): Geol. Soc. America, Abstracts with Programs, v. 2, n. 7, p. 639.

Structural data and features suggesting shock deformation are interpreted as reasonable evidence that the Decaturville structure is an astrobleme; its age is Triassic as indicated by fission-track determinations for apatite.

Palmer, James E., 1966, Some geological and magnetic characteristics of buried and resurrected Precambrian hills of southeastern Missouri: Unpubl. Doctoral dissertation, Univ. Missouri-Rolla, Rolla, Missouri.

Structural and magnetic characteristics around six Precambrian outcrops (Little Pilot Knob, Czar Knob, Taum Sauk area, Eminence Knob, Caledonia, and Sullivan) were studied in detail. The origin of peripheral dips in sediments is ascribed to compaction of lime muds. Depositional environments adjacent to Precambrian hills are discussed. The magnitude of structural relief above Precambrian hills is dependent upon the size, height, and steepness of the buried hill, and the compactibility of overlying sediments. Variable magnetic anomalies over buried hills are due largely to variations in magnetic susceptibilities of the igneous rocks. Computed aeromagnetic anomalies by use of the surface integral method should aid in recognition of anomalies associated with buried Precambrian hills on aeromagnetic maps. - M.G.S. manuscript file.

Park, Frederick B., 1968, Remanent magnetism and the anomaly at Cottoner Mountain, Madison County, Missouri: *Geophysics*, v. 33, n. 4, p. 613-620.

Not available for review.

Paul, R. W., 1969, Petrographic and micropaleontologic studies of the Decaturville disturbance in Missouri: A progressive report (abs.): *Geol. Soc. America, Abstracts with Programs for 1969, South-Central Sec.*, p. 23.

86 test wells near the center of the area recovered about 8,000 meters of core. Petrographic study of the cores indicates extremely complex brecciation of subsurface formations.

\_\_\_\_\_, 1970, The age and origin of the Decaturville structure, Camden and Laclede Counties, Missouri: Unpubl. Masters thesis, Univ. of Kansas, Lawrence, Kansas.

Diagnostic characteristics of the Decaturville structure are similar to those of known meteorite impact structures. - M.G.S. manuscript file.

Phelan, Michael Joseph, 1969, Crustal structure in the central Mississippi valley earthquake zone: Unpubl. Doctoral dissertation, Washington Univ., St. Louis, Missouri.

This study integrates seismic crustal data with gravimetric and magnetic information into a crustal interpretation of southeast Missouri including the area to the south and east of Fulton in Callaway County. The upper 25 km of the crust is predominantly sialic and consists of two major silicious terranes; ultramafic rocks occur at Malden and Bloomfield, along the NE flank of the Pascola arch. Several crustal lineaments are defined on the basis of geophysical data; earthquakes are concentrated along these lineaments, where they intersect each other, or where they cross the Pascola arch. Uplift due to mass deficiencies in the upper crust is considered to be a contributing cause of regional arches and domes in the Midcontinent. Since the early Paleozoic; mass deficiencies were probably caused by the intrusion of low density silicious material into the upper crust in the Precambrian. - M.G.S. manuscript file.

Phelan, Michael and Emil J. Mateker, 1967, Geologic implications of geophysical data along the eastern flank of the Ozark uplift (abs.): Geol. Soc. America, North-Central Sec., Program 1967 Ann. Mtg., p. 19-20.

Relative Bouguer gravity high over the St. Francois Mountains suggests that the "core" of the mountains consists of rocks denser than felsites. Gravity low over the Crooked Creek structure indicates a large vent filled with low density material. Low amplitude relative gravity high over the Lincoln fold indicates that it is not associated with a basic intrusion. The upper segment of the crust along the eastern flank of the Ozark uplift consists of block-like elements, including high-density rocks. Some of these blocks form lineaments associated with lines of earthquake epicenters, suggesting that earthquakes on the craton are associated with old, but major, lines of crustal weakness.

Robertson, Forbes, 1965, Petrology of the St. Francois Mountains batholith, Missouri (abs.): Geol. Soc. America, Program 1965 Ann. Mtgs., p. 135-136.

The batholith was emplaced within the volcanic pile in two stages as an essentially concordant orthomagmatic body. First-stage, fine grained sodalite granite occurs in discontinuous sill-like bodies; second-stage granite differentiated in place from kalsilite to adamellite; most contacts between granites are gradational. The younger volcanic materials, the granites of the batholith, and the diabasic rocks are believed to compose a single petrogenetic unit.

Rudman, A. J., C. H. Summerson and W. J. Hinze, 1965, Geology of basement rocks in midwestern United States: Am. Assoc. Petroleum Geologists Bull., v. 49, p. 894-904.

This report includes primarily Illinois, Indiana, Michigan, Ohio, and Kentucky. Basement drill hole locations in Missouri are shown in several of the figures. Configuration of the basement surface, ages and orogenic trends, basement lithology and structure are discussed. An integrated approach utilizing drill hole data and geophysical surveys is advocated for maximum understanding of the geology of the buried basement.

Sandell, E. B. and S. S. Goldich, 1943, The rarer metallic constituents of some American igneous rocks: I, II: Jour. Geology, v. 51, p. 99-115, 167-189.

Seven samples from St. Francois Mountains (3 granite, 2 rhyolite, 1 diabase, and 1 aplite) were analyzed for Mo, Pb, Zn, Cu, Ni, and Co. A series of variation curves relate the distribution of metallogenic elements to igneous rock types. Comparison with other areas shows the Missouri granites to be unusually rich in lead, the Skrainka diabase to be deficient in copper, and the ratio of zinc to total iron to be above average in the Missouri samples. The granitic rocks from the St. Francois Mountains show marked similarities to those from the Llano uplift of Texas in both their bulk chemical composition and heavy metal content.

Satterfield, Ira R., 1966, Petrographic and modal analysis of the andesite of Marble Creek, southeastern Missouri: Transactions of the Illinois State Academy of Science, v. 59, n. 3, p. 207-211.

Porphyritic andesite, with abnormally high percentage of plagioclase and quartz, and only minor amounts of biotite, hornblende, and augite, is believed to be a flow. - M.G.S. reprint file.

Scharon, LeRoy and Marvin Ehrlich, 1964, Paleomagnetic research in Missouri (abs.): Missouri Acad. Science Proc., v. 1, ser. 2, p. 37.

Summary of results of paleomagnetic investigations at Washington University on hundreds of samples collected from the St. Francois Mountains.

Scharon, LeRoy, Walter Hays and R. Ernest Anderson, 1961, Paleomagnetic investigations in the St. Francois Mountains in Guidebook to the geology of the St. Francois Mountain area: Mo. Geol. Survey and Water Resources, Rept. Inv. 26, p. 106-114.

The following measurements were made on 248 samples of igneous rocks from St. Francois Mountains: 1, direction and intensity of remanent magnetization, 2, magnetic susceptibility and direction of susceptibility anisotropy, and 3, partial demagnetization. The results indicate that the Stouts Creek, Hogan Mountain, and Royal Gorge rhyolites are contemporaneous and possibly genetically related, and that the Iron Mountain andesite and the Skrainka diabase may be contemporaneous with the rhyolites, all five rock units representing a relatively short interval of Precambrian time.

Schnepfe, Robert N., 1962, Density and susceptibility measurements, St. Francois Mountains area, Missouri: Unpubl. rept., Mo. Geol. Survey and Water Resources, Rolla, Missouri.

Several hundred samples of Precambrian rocks, both from outcrop and from the subsurface, were used for the determinations. - M.G.S. manuscript file.

Schwendinger, William W., 1950, A detailed resistivity survey with references to the cause of the magnetic anomaly immediately southeast of St. Charles in St. Louis County, Missouri: Unpubl. Masters thesis, St. Louis Univ., St. Louis, Missouri.

Not available for review.

Segar, Robert L., 1965, A gravity and magnetic investigation along eastern flank of the Ozark uplift: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

Includes Perry, and parts of Ste. Genevieve, St. Francois, Madison, Bollinger and Cape Girardeau Counties, extending into Illinois. The Perry County gravity anomaly is interpreted as a basic intrusion at 4,400 feet depth; it is suggested to have indirectly been the determinant element for the lines of faulting in this region. The Higdon anomaly can be attributed to faulting. The Greasy Creek (near Avon) and Brewerville anomalies are shown on the magnetic map. Drilling at Greasy Creek encountered basic and granitic material from 674 to 1,094 feet. Both magnetic highs are interpreted as the result of large circular dikes or plugs in the basement. - M.G.S. manuscript file.

Smith, Frederick, 1968, Mineralization of the Boss-Bixby anomaly, Iron and Dent Counties, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Study of mineral paragenesis and zoning by petrographic and X-ray analyses of 73 drill core samples from the Boss-Bixby iron-copper deposit. The Precambrian rocks include nine different units of rhyolite, syenite, diorite, andesite, and granite intrusives, and metamorphic rocks (contact metamorphosed rhyolite, biotite schist, and possible "migmatites"). The sequence of igneous events is described; ore mineralization occurred after intrusion of intermediate magma, but prior to the intrusion of granite. Ore minerals in order of deposition are recognized as magnetite, ilmenite, geikielite, hematite, rutile, pyrite, molybdenite, cobaltite, chalcopyrite, bornite, sphalerite, galena, limonite, chalcocite, and cuprite. Four different types of zoning indicate that the temperature and partial pressure of oxygen and sulfur controlled ore deposition. The deposit is classified as a pyrometasomatic deposit; source of mineralization is postulated to be an intermediate magma. - M.G.S. manuscript file.

Snyder, Frank G., 1966, Precambrian iron deposits in Missouri (abs.): Econ. Geology, v. 61, n. 4, p. 799.

The Iron Mountain, Pea Ridge, Pilot Knob, and Bourbon deposits are believed to be closely related to their felsite host rocks, and are probably derived from the same magmatic source.

\_\_\_\_\_, 1968a, Geology and mineral deposits, Midcontinent United States in Ore deposits of the United States, 1933-1967, Volume 1, John D. Ridge, Ed.: Am. Inst. Min., Met. and Petroleum Eng., p. 257-286.

Major Midcontinent Precambrian events are summarized. Clastic sediments across central Missouri, Kansas and Nebraska are inferred to have metamorphosed during the 1,700 m.y. Penokean orogeny; intrusion of intermediate to mafic magmas in Missouri occurred 1,500 m.y. ago, followed by the St. Francois igneous activity. The belt of volcanics from Ohio to Texas is interpreted as a "continental divide" during late Precambrian and early to middle Cambrian time. Precambrian iron deposits of Missouri are reviewed (Greasy Mine, Iron Knob, Pilot Knob, Iron Mountain, Bourbon, Pea Ridge, Kratz Springs, Camels Hump, and Boss). It is suggested that the iron is a differentiate from the magma that formed the rhyolites and granites of the St. Francois Mountains. - M.G.S. library.



\_\_\_\_\_, 1968b, Tectonic history of midcontinental United States: U.M.R. Jour., no. 1, ser. 1, p. 65-77.

Precambrian history of central stable region reviewed. Oldest dated igneous rocks in Missouri (1,500 m.y.) may represent waning stages of middle Precambrian Penokean orogeny. In Audrain County they cut what is interpreted as steeply dipping Huronian type sequence of quartzite, slate, and schist. Late Precambrian igneous rocks from 1,100 to 1,450 m.y. of age appear to be unrelated to any orogenic cycle; sequence of extrusion and intrusion was essentially continuous. Several distinct stages of intermediate to mafic intrusive activity are postulated. The younger mafic rocks of Missouri probably belong to the Keweenawan igneous activity. The belt of volcanic rocks forming Precambrian outcrops and subcrops from Ohio to Texas is termed the "Ancestral Ozarks" and interpreted as a continental divide in Late Precambrian time. Paleozoic time was characterized by differential subsidence and uplift; cryptoexplosion structures developed along pre-existing structural axes. - M.G.S. library.

\_\_\_\_\_, 1969, Precambrian iron deposits in Missouri in Magmatic ore deposits -- a symposium, H.D.B. Wilson, Ed.: Econ. Geology, Mon. 4, p. 231-238.

See Snyder, 1968a and 1968b.

\_\_\_\_\_, 1970, Structural lineaments and mineral deposits, eastern United States in Volume I, Mining and concentrating of lead and zinc, Donald O. Rausch and Burt C. Mariacher, eds.: AIME World Symposium on mining and metallurgy of lead and zinc, v. 1, p. 76-94.

Cryptoexplosion structures, alkalic igneous rocks, and mineral districts are considered as expressions of a single set of forces and processes deep within the earth. They represent release of gas, magma, and heat, respectively, along major crustal breaks from the lower crust or upper mantle. They define major east-west lineaments, such as the 38th parallel lineament, and the Tennessee and Galena lineaments, described in this paper. The lineaments are believed to be continental effects of major transcurrent faults in the ocean basin or mantle currents beneath the continent. They may be useful in locating target areas for base metal exploration. - M.G.S. library.

Snyder, Frank G. and Paul E. Gerdemann, 1965, Explosive igneous activity along an Illinois-Missouri-Kansas axis: American Jour. Science, v. 263, p. 465-493.

The Avon diatremes, Furnace Creek volcanic crater, Crooked Creek disturbance, Hazel Green volcanics, Decaturville disturbance, and Weaubleau fault zone of Missouri are aligned in a 400-mile east-west trending structural zone. A basement zone of weakness is suggested which provided an avenue for basic magma or gases to ascend. These structures are believed to be closely related in mode of origin to intermittent deep-seated faulting and intrusion through a long period of time. - M.G.S. reprint file.

Snyder, Frank G. and Richard E. Wagner, 1961, Precambrian of southeast Missouri; status and problems in Guidebook to the geology of the St. Francois Mountain area: Missouri Geol. Survey and Water Resources, Rept. Inv. 26, p. 84-94.

This paper reviews the exposed Precambrian sequence as established by field relationships, discusses previous petrographic, chemical, heavy mineral, trace element, isotopic, and magnetic studies, and summarizes the Precambrian history of the region.

Southern Interstate Nuclear Board, 1969, Uranium in Missouri in Uranium in the southern United States: U. S. Atomic Energy Comm., p. 24-36.

Report of above background radioactivity in specular hematite from Pilot Knob and in altered granite from Silvermine. The uranium resources and potential of Missouri are reviewed. - M.G.S. reprint file.

Sproule, J. C., 1957, Clastic reservoirs on the Precambrian surface in North America: Am. Assoc. Petroleum Geologists Bull., v. 41, p. 848-860.

"Granite wash"-type sediments around Precambrian paleotopographic features are discussed with particular reference to sedimentary basins that flank the Precambrian shield and related buried Precambrian islands.

Stainbrook, Don J., 1966, Heat flow in the Boss deposit of Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Thermal conductivity measurements of drill cores from the Boss iron-copper deposit. The calculated attitude of high and low thermal conductivity zones was used to interpret the geologic structure. - U.M.R. library.

Stewart, S. W., 1966, Seismic ray theory applied to refraction surveys of the Earth's crust in Missouri: Unpubl. Doctoral dissertation, St. Louis Univ., St. Louis, Missouri.

Not available for review.

\_\_\_\_\_, 1968, Crustal structure in Missouri by seismic refraction methods: Seismol. Soc. America Bull., v. 58, n. 1, p. 291-323.

Not available for review.

Tikrity, Sammi Sherif, 1968, Tectonic genesis of the Ozark uplift: Unpubl. Doctoral dissertation, Washington Univ., St. Louis, Missouri.

Subsurface and geophysical data were utilized in the construction of a structural map of southeast Missouri. Three tectonic elements are recognized, the Ozark Arch, the St. Francois Dome, and the Decaturville Dome; the central part of each is underlain by granitic Precambrian basement; these were structurally higher than the felsitic, metamorphic, and basic basements of the surrounding regions in Precambrian time.

Basement faulting was the primary factor in the delineation of the tectonic and structural pattern of the area. Lighter, granitic blocks of the earth's crust were moving upward in stages through geologic time. The tectonic forces that moved these blocks differentially were vertical, and the dominant structural style is one of block faulting - M.G.S. manuscript file.

Tikrity, Sammi Sherif, Emil J. Mateker and Norman S. Hinchey, 1967, Geological-geophysical investigation of faulting along the eastern flank of the Ozark uplift (abs.): Geol. Soc. America, North-Central Sec., Program 1967 Ann. Mtg., p. 22.

The source of anomalous gravity and magnetic anomalies of major faults along the eastern flank of the Ozark uplift appears to be in the Precambrian. It is suggested that the Cap au Gres fault does not have a strike-slip component.

Tikrity, Sammi Sherif and Emil J. Mateker, 1968, Precambrian ancestors of the Ozark uplift (abs.): Geol. Soc. America, program 1968 Ann. Mtg., North-Central Sec., p. 39.

The idea that major Paleozoic uplifts had their "roots" in Precambrian time is supported by structural evidence.

Tilton, G. R., G. W. Wetherill and G. L. Davis, 1962, Mineral ages from the Wichita and Arbuckle Mountains, Oklahoma, and from the St. Francois Mountains, Missouri: Jour. Geophysical Research, v. 67, n. 10, p. 4011-4019.

Micas and feldspars in Silvermine and Graniteville granites give ages of 1,300 to 1,450 m.y.; associated zircons have discordant U/Pb ages. The crystallization of these rocks may have occurred 1,400 to 1,550 m.y. ago. Precambrian age for pegmatite at Decaturville is established. An orogeny is postulated to have occurred about 1,500 m.y. ago. Rocks of the St. Francois and Arbuckle Mountains are correlated with pegmatites and granites to the west in New Mexico and Arizona. The pattern of distribution of ages on the North American continent is successively younger to the south and east toward the margin of the continent. - M.G.S. reprint file.

Tolman, Carl and Forbes Robertson, 1969, Exposed Precambrian rocks in southeast Missouri (contribution to Precambrian Geology No. 1): Mo. Geol. Survey and Water Resources, Rept. Inv. 44, 68 p.

The pre-batholithic, batholithic, and post-batholithic rocks, their age relations, distribution, and petrographic character are described in detail. The geologic map is at a scale of 1:250,000.

U. S. Air Force Aeronaut. Chart and Inform. Center, Compiler, 1968, Transcontinental geophysical survey (35°-39° N), Bouguer gravity map from 87° to 100° W longitude: U. S. Geol. Survey Misc. Geol. Inv. Map I-534-B, scale 1:1,000,000.

Contribution to the Upper Mantle Project. Includes southern Missouri.



Vincenz, S. A., G. J. Braught and A. C. Meyers, 1965, Thermal demagnetization of some Precambrian igneous rocks of Missouri in The symposium on magnetism of the earth's interior: Jour. Geomagnetism and Geoelectricity, v. 17, p. 337-355.

Not available for review.

Vistelius, Andrew B. and Vernon J. Hurst, 1964, Phosphorous in granitic rocks of North America: Geol. Soc. America Bull., v. 75, p. 1055-1092.

Frequency distribution of phosphorous in granitic rocks, correlation of major elements and their norms with phosphorous, and correlation of modal composition and phosphorous concentration were investigated in 602 analyses of granitic rocks in North America, including 24 analyses from Missouri. The Missouri samples fall in the "Texan type" distribution pattern of phosphorous in granitic rocks, indicating auto-metamorphic leaching of apatite by acid solutions.

Wagner, Richard E. and Eva B. Kisvarsanyi, 1969, Lapilli tuffs and associated pyroclastic sediments in Upper Cambrian strata along Dent Branch, Washington County, Missouri: Mo. Geol. Survey and Water Resources, Rept. Inv. 43, 80 p.

Early Paleozoic volcanic center near the 38th parallel lineament is described.

Warren, David H., 1968, Transcontinental geophysical survey (35°-39° N), seismic refraction profiles of the crust and upper mantle from 87° to 100° W longitude: U. S. Geol. Survey Misc. Geol. Inv. Map I-534-D, scale 1:1,000,000.

Contribution to the Upper Mantle Project. Includes southern Missouri.

Weixelman, Wesley D., 1959, Geology of the northeast portion of Des Arc Quadrangle, Iron and Madison Counties, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Exposed Precambrian rocks, from oldest to youngest, are mapped as purple rhyolites with an interlayered tile-red rhyolite, andesine basalts with interlayered tuff, and a dacite-andesite. A diabase dike intrudes the lower purple rhyolite; several quartz veins are noted. The tuff associated with the basalt is reported to contain 37% hematite, 35% calcite, 5% quartz, and 3% magnetite; it is about 30 feet thick, and is considered as a possible low-grade iron ore (28% iron content estimated). - M.G.S. manuscript file.

Wheeler, Harry E., 1965, Ozark pre-Cambrian-Paleozoic relations: Amer. Assoc. Petroleum Geologists Bull., v. 49, p. 1647-1665.

Felsite-Paleozoic contacts are interpreted as tectonic rather than depositional; topographically high felsites above Paleozoic strata in the St. Francois Mountains are considered to have been overthrust from the SW in latest Permian time.

Wills, Bonnie and Nancy Bertram, compilers, 1959, Bibliography of Missouri Precambrian: Mo. Geol. Survey and Water Resources, Misc. Publ., 15 p.

This bibliography lists 201 individual entries.

Yen, Luis, 1963, Paleomagnetic investigations of a gabbroic dike in the the St. Francois Mountains, Missouri: Unpubl. Masters thesis, Washington Univ., St. Louis, Missouri.

12 samples of Skrainka gabbro from Devils Toll Gate were studied. The magnetization of the unit was defined as a thermal remanent magnetization. Remanent magnetization intensities of the rock are not entirely a function of the volume of iron and titanium minerals. Seven ground magnetic traverses were made and correlated with the aeromagnetic data. - M.G.S. manuscript file.

Zablocki, Charles J., 1960, Measurements of electrical properties of rocks in southeast Missouri in Geological Survey research: U. S. Geol. Survey, Prof. Paper 400-B, p. B214-B216.

Self potential, resistivity, induced polarization, and magnetic susceptibility measurements were made of Precambrian rhyolite, granite, and quartz monzonite penetrated by 6 drill holes in southeast Missouri, using inhole logging methods.

Zietz, Isidore, Elizabeth R. King, Wilburt Geddes, and Edward G. Lidiak, 1966, Crustal study of a continental strip from the Atlantic Ocean to the Rocky Mountains: Geol. Soc. America Bull., v. 77, p. 1427-1448.

Includes northern Missouri. Twenty aeromagnetic profiles in a 100-mile-wide strip reveal large anomalies and disclose several magnetic patterns that reflect basement lithology and structure. One major linear magnetic feature extends nearly 500 miles across Nebraska and Iowa southeastward to near the NE corner of Missouri and may mark a zone of east-west rifting; these features may originate in the upper mantle.

Zietz, Isidore, and J. R. Kirby, 1968, Transcontinental geophysical survey (35°-39° N), magnetic map from 87° to 100° W longitude: U. S. Geol. Survey Misc. Geol. Inv. Map I-534-A, scale 1:1,000,000.

Contribution to the Upper Mantle Project. Includes southern Missouri.

Zimmerman, Richard A., 1959, Geology of the Annapolis area, Iron County, Missouri: Unpubl. Masters thesis, Univ. Missouri-Rolla, Rolla, Missouri.

Includes central part of the Des Arc 15-min. quadrangle. Four varieties of rhyolite are mapped and one occurrence of diabase is noted. - M.G.S. manuscript file.

## CONTRIBUTIONS TO PRECAMBRIAN GEOLOGY

The following Reports of Investigations have been published by the Missouri Geological Survey (now a part of the Missouri Department of Natural Resources) in a special series entitled *Contributions to Precambrian Geology*. This volume is the sixth contribution in the series.

RI 44 — EXPOSED PRECAMBRIAN ROCKS IN SOUTHEAST MISSOURI (Contribution to Precambrian Geology No. 1), by Carl Tolman and Forbes Robertson, 74 p., 2 pls., 3 figs., May 1969. Price \$2.00.

RI 46 — ASH-FLOW TUFFS OF PRECAMBRIAN AGE IN SOUTHEAST MISSOURI (Contribution to Precambrian Geology No. 2), by Ernest Anderson, 56 p., 1 pl., 8 figs., 1 tbl., April 1970. Price \$1.00.

RI 47 — MAFIC INTRUSIVE ROCKS OF PRECAMBRIAN AGE IN SOUTHEAST MISSOURI (Contribution to Precambrian Geology No. 3), by Dewey H. Amos and George A. Desborough, 28 p., 3 pls., 3 figs., 2 tbls., 1970. Price \$2.00.

RI 51 — PETROCHEMISTRY OF A PRECAMBRIAN IGNEOUS PROVINCE, ST. FRANCOIS MOUNTAINS, MISSOURI (Contribution to Precambrian Geology No. 4), by Eva B. Kisvarsanyi, 51 p., 1 pl., 7 figs., 3 tbls., 2 app., 1972. Price \$.75.

RI 56 — DATA ON PRECAMBRIAN IN DRILLHOLES OF MISSOURI INCLUDING ROCK TYPE AND SURFACE CONFIGURATION (Contribution to Precambrian Geology No. 5), by Eva B. Kisvarsanyi, 24 p., 1 pl., 1 tbl., 1975. Price \$.75.

(this volume)

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