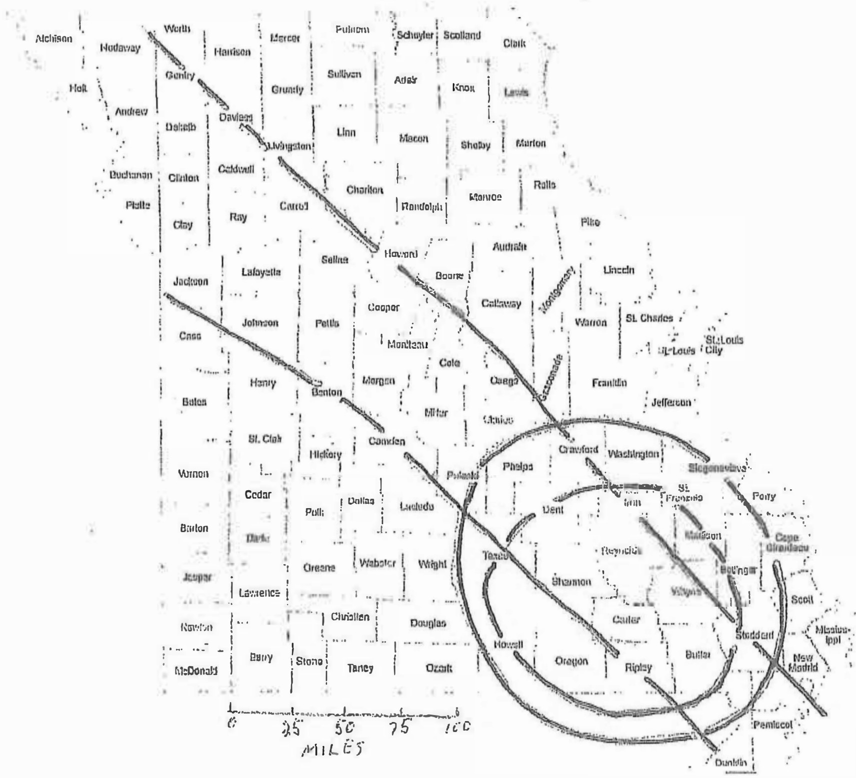
POSSIBLE PRECAMBRIAN ASTEROID IMPACT STRUCTURE IN SOUTHEAST MISSOURI AND EFFECTS ON GEOLOGY AND PUBLIC HEALTH



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The high incidence of CANCER and KIDNEY DISEASE in southeastern Missouri appears to have a direct connection with GEOLOGY that can be traced as far back as the impact of a large ASTEROID ~1,500,000,000 years ago.

Areas with the highest cancer rate generally lie along the east side of the proposed ASTEROID IMPACT STRUCTURE where SANDSTONE is the surface rock. That's likely not due to sandstone itself, but from materials in groundwater flowing through the sandstone, particularly in the Roubidoux and Lamotte sandstone formations.

The high cancer rate appears to be a synergistic effect of SMOKING and of GEOLOGICAL CARCINOGENS most likely present at TRACE ELEMENT concentration and effective only upon chronic exposure from drinking domestic well water and consuming food originating from plants grown on local soil and eating wild and domestic animals grazing locally. Radon, radium, and uranium in well water are particularly suspect, especially along faults.

If this project is successful, what might be accomplished?

• **New cases (ONLY)** of certain kinds of cancer and kidney disease in southeast Missouri could be reduced by 50% within 25 years and continue to decline thereafter if a geological cause is confirmed and remediation is successful. Particularly if smoking also declines. Disease **prevention** appears possible. **No claim is made for potential CURE of already existing cases of disease.**

• Minerals exploration in southeast Missouri could discover Olympic Dam-type ore deposits and additional ore deposits of other types including significant uranium recovery from groundwater and from massive uranium and associated minerals deposits in rock in Carter and bordering counties, resulting in vibrant mining and manufacturing industries including high-tech firms using locally produced byproduct rare-earths.

An interesting sidelight is the perfect fit between the proposed Asteroid Impact Structure and the contiguous area of high smoking rates. Probably a coincidence, but the fit is so close that there may be a connection. Smoking did not cause the impact, so is impact structure geology possibly causing heavy smoking? Far-fetched? Certainly. But maybe real. Your thoughts are welcome on this unusual correlation.

Thanks go to the Salem, Missouri, SALEM NEWS for permission to use the newspaper's material in this report.

William Jud, Geologist

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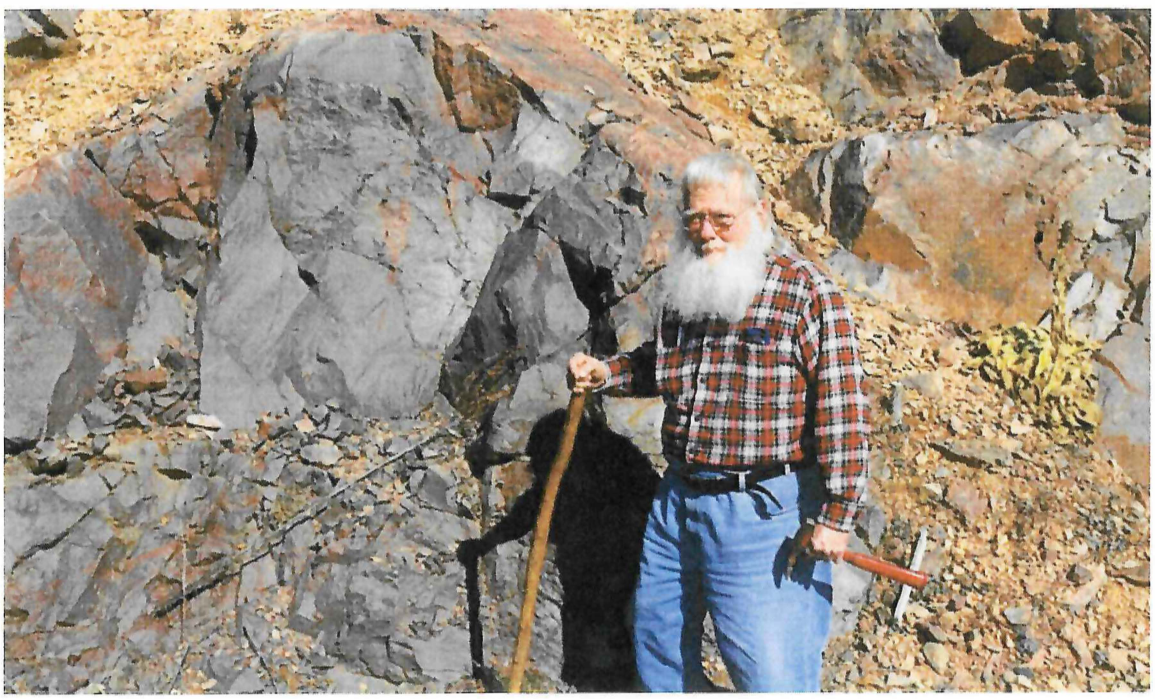

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INTRODUCTION

Often the fun part of any project is startup, when wild speculation within the bounds of reality allows flights of imagination into the POSSIBLE without the tedious slog through the PRACTICAL that follows. Think about it now. Prove it later.

This article is based on the recognition that a large circular 'Low Gravity' feature in southeast Missouri may indicate a Precambrian **ASTEROID IMPACT STRUCTURE**, how that structure might interact with other geological features and people, including effects on cancer and kidney disease, and what it all could mean. A reasonable geological interpretation is developed.

Some geologists look at the map and don't see a circular gravity 'low'. I see it. Not big, bold, and obvious, but it's there. Complicated and a bit scrambled by association with the Missouri Batholith, but it's there. I find the image is much easier to see on a glowing computer monitor screen than on a printed page.

This report assumes the Asteroid Impact Structure is real and develops geological, economic, public health, and related features derived from that assumption.

There are no known Impact Structure rocks or other physical evidence at this time. Data points are scattered and very few. Impact structures should show shatter cones, shocked quartz, and the high-pressure quartz polymorph mineral Coesite. But this impact structure is eroded, buried under volcanic and marine sedimentary rocks, and too deep to observe shatter cones. Shocked quartz and Coesite would have been reset or outright melted by the intruding Missouri Batholith, including within xenoliths brought up in volcanic material.

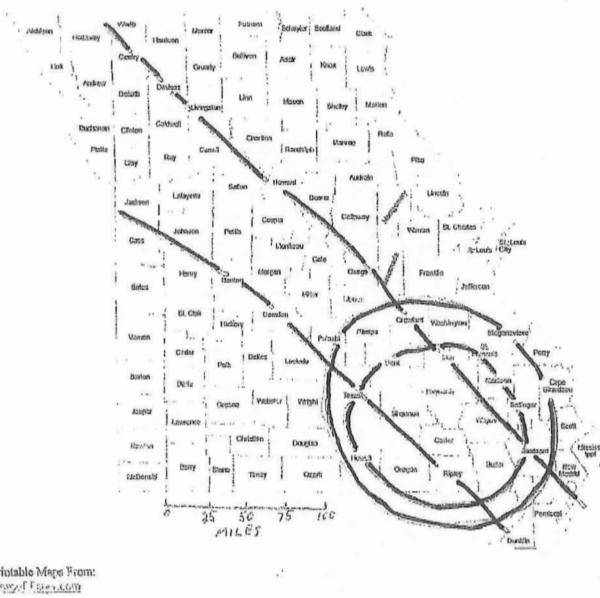
Crater fill material has not been exposed in drill core, deep mines, or found in the Avon diatremes. No Precambrian crater fill sandstone or Suevite impact breccia xenoliths have been found in granite, volcanic rock, or in other Missouri impact structures. Definitive geophysics, particularly a seismic line across the entire low gravity circle, are not yet done.

The proposed impact, Crater, and derivatives are only a geological theory now, but future studies may prove they exist. Way more information and economic incentives to obtain that information are needed to confirm or disprove the impact structure's existence.

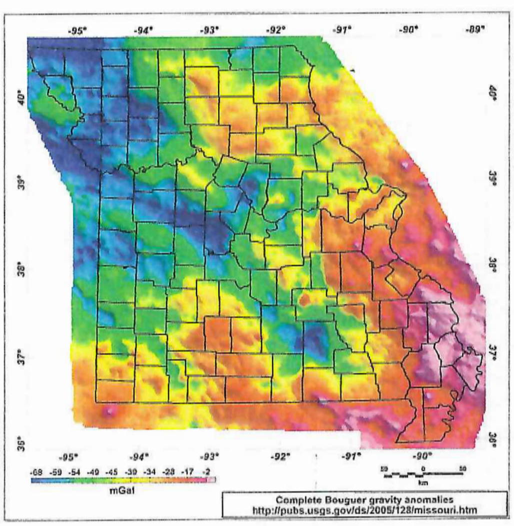
This document is a compilation of geological and public health information intended to be a roadmap for research. Actual research has not yet happened.

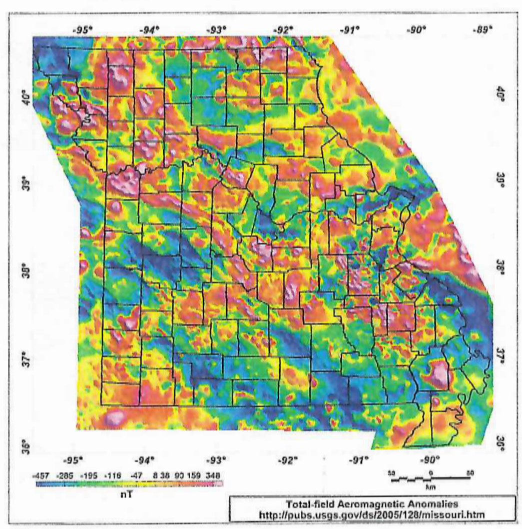
Stay tuned.

THE PROPOSED ASTEROID IMPACT STRUCTURE, MISSOURI COUNTIES, AND MISSOURI BATHOLITH.



MISSOURI GRAVITY	MISSOURI MAGNETIC





One day about 1,500,000,000 years ago an ASTEROID bigger than the asteroid that killed the dinosaurs slammed into Precambrian Supercontinent COLUMBIA. About 1,350,000,000 years ago LAURENTIA broke off from Columbia and became a separate continent, taking with it the land that would become Missouri.

~1,500,000,000 years of Tectonic Plate movement after impact, the Asteroid's Crustal impact site is now in southeast Missouri.

There is a large circular area, 125 miles in diameter, of lower gravity intensity shown in southeastern Missouri on the Missouri Gravity map. The Missouri Magnetic map does not show this feature. Gravity YES + Magnetic NO usually indicates the low gravity causative agent is deeply buried. Or maybe there isn't much density and magnetic difference between the crater rocks and surrounding regional rock types. Probably a combination of depth, density, and low magnetic contrasts.

The low gravity feature is way too big to be another of the several ancient Precambrian collapsed caldera volcanos known in southeast Missouri and probably is too small to be a normal Mantle Plume or another kind of really big circular geological structure.

Most likely, lower gravity intensity and lack of a coincident magnetic signature indicate that some weakly magnetic, lower-density rock deeply underlies the circular low-gravity area.

What could it be? What does it mean? Could there be economic or other importance?

The impact structure extends a little way into northern Arkansas. In Missouri, 23 counties are partly or entirely within the impact area: Bollinger; Butler; Cape Girardeau; Carter; Crawford; Dent; Dunklin; Howell; Iron; Madison; Oregon; Perry; Phelps; Reynolds; Ripley; Scott; Shannon; St. Francois; Ste. Genevieve; Stoddard; Texas; Washington; Wayne.

The impact area center includes Carter county (Van Buren), southern Reynolds county (Ellington), and western Wayne county (Piedmont).

Extending nearly 400 miles northwest from the Crustal, gravity-indicated, circular impact site in present-day southeastern Missouri, to the presumed actual Precambrian Crustal impact site in present-day southeastern Nebraska, is a trail 50 miles or more wide of lower gravity named the Missouri Gravity Low (MGL) atop the Missouri Batholith.

MGL's lower gravity intensity is caused by lower density igneous rock created from granite magma generated by a small and temporary Mantle Plume resulting from the Asteroid impact. That lower density granite magma intruded higher density rocks that populate adjacent lower regions of Earth's Crust. Some of MGL's lower gravity intensity may be caused by buried lenses of lower density sedimentary rock resulting from sediments filling graben valleys down-dropped between border faults. These possible, and likely extensive if they exist, lenses of valley sedimentary rocks within MGL, in contact with frequently reactivated and deeply extending major border faults, and above intruding granite magma, are good targets for IOCG and other kinds of minerals exploration.

The Missouri Batholith is estimated to be a vertical slab of buried granite 77 miles wide, at least 372 miles long, and 7 miles thick, with an average depth from land surface to batholith top of about 3 miles.

The Gravity map shows the outlined Missouri Batholith trail of weaker gravity crossing Missouri from the northwest corner to the southeast Reelfoot Rift corner. A color transition crosses the map northeast to southwest almost across the middle of the map. Northwest of the transition, map colors are mainly green and blue, representing weaker gravity intensity. Southeast of the transition, map colors are mainly yellow, red, and purple representing stronger gravity.

The mostly blue, green, and yellow, lower density, Missouri Batholith granite (+ internal sedimentary rocks?) cuts an obvious NW/SE swath of weaker gravity through the red and purple area of stronger gravity. Missouri Batholith granite intrudes and displaces, but does not combine with, older Precambrian gneiss/schist along the Missouri Gravity Low outside and northwest of the Impact Crater.

In the Impact Crater conditions were different because of the extensive fracture column. Intruding granite magma did not shove aside existing gneiss and schist as happened along the Missouri Gravity Low. Granite magma filled open space within the extensive fracture column resulting in a composite gravity signal of granite + gneiss + schist.

Average granite density is 2.64 g/cc. Average gneiss density is 2.8 g/cc. Average schist density is 2.64 g/cc. There is some, but only a little, density difference between the intruding Missouri Batholith granite and the Impact Crater's fracture column gneiss/schist host rock. The Impact Structure composite gravity intensity is weaker than the gravity intensity from surrounding regional gneiss/schist. But only a little weaker, and detectable as a mild, circular, complex gravity 'low' at the surface above the impact site. Were it not for the purple, outlining, higher density rocks in the ring dike around the impact structure, the circular gravity 'low' structure on the map might not be noticed at all.

It is a subtle pattern more easily seen on a glowing computer monitor screen than on a printed page. The low gravity image would be obvious if the Crater landform and Crater-fill sediments still existed, if granite/schist/gneiss mixed rock density contrast were bigger, and if the impact crater were not so deep and not covered by a thick layer of volcanic and sedimentary rock. One works with what one has.

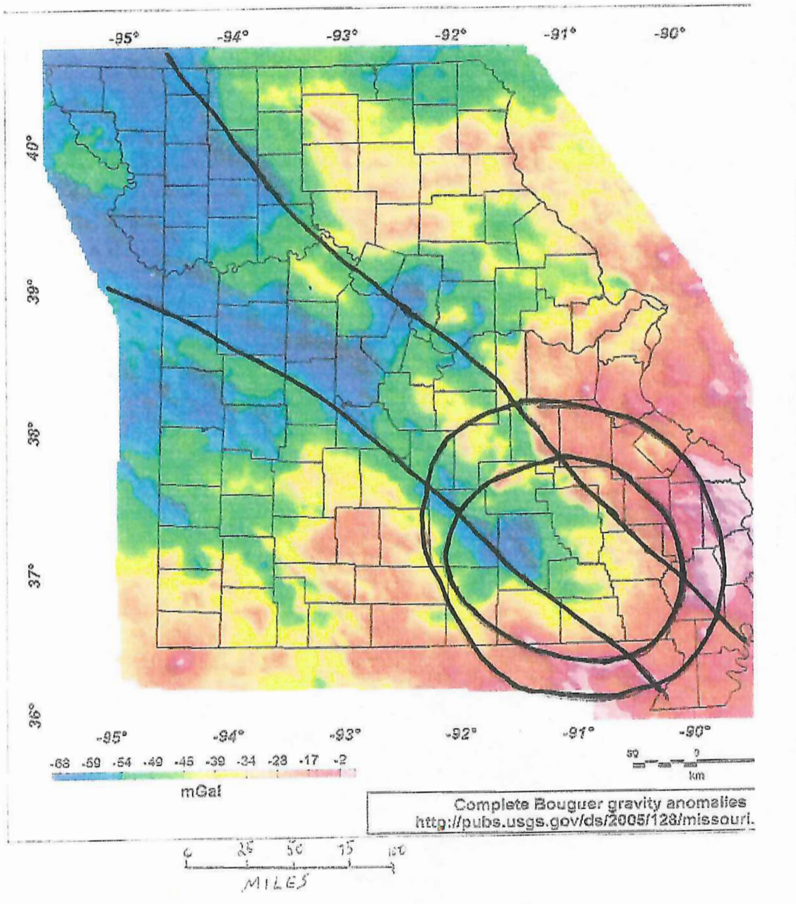
Magma cupolas atop the batholith broke through to the Precambrian paleosurface. The resulting volcanic eruptions formed the extensive Saint Francois Precambrian volcanic province.

Mantle Plumes operating today, and similar to but much larger than the Plume the Asteroid started, power volcanic eruptions at Yellowstone Park and Hawaii.

Lower density Missouri Batholith granite is 'floating' within adjacent and underlying higher density rocks, causing isostatic adjustment uplift responsible for higher land elevations that have persisted throughout Iron County and vicinity since Precambrian time more than a billion years ago. Lower density granite intruded into higher density regional rocks is the geological equivalent of icebergs and low-density wood floating in water.

How do these features combine to produce a circular Gravity 'low'?

GEOLOGICAL INTERPRETATION OF THE GRAVITY MAP.



TIME ZERO -- IMPACT.

WHAM! ~1,500,000,000 years ago, an asteroid thought to have been 10 miles wide slammed into Supercontinent Columbia on Planet Earth in present-day southeastern Nebraska.

Supercontinent Columbia existed from 1.8 Ga to 1.3 Ga and included the future southeast Missouri. Ga = Giga-annum = a billion years.

Asteroid impact blasted out a huge crater.

In materials that impactors penetrate, surface crater shape vs. crater depth generally depends on impactor size. A rifle bullet or even a cannonball drills a hole much deeper than the width of the entry hole. A larger impactor such as the meteorite thought to have been about 160 feet wide that created Barringer Meteor Crater in Arizona, left a hole a mile wide and 500 feet deep -- a Salad Bowl shape. The bigger the impactor the bigger and flatter the crater. Really big impact craters such as the largest craters you see on the Moon usually have a Dinner Plate shape, much wider than deep, an overall flat floor, and may have other features such as a ring anticline/syncline pattern and a raised peak central landform.

The Precambrian Asteroid that left its mark on present-day southeast Missouri blasted out a large Dinner Plate type of Crater.

It is possible that the central peak ring shown on the Missouri Gravity map is an igneous Ring Intrusive and not an impact landform.

A hemispherical impact shock wave propagated down through the Crust into the Asthenosphere. The bowl-shaped shock wave spread wider upward as the center of the wave went deeper. Impact kinetic energy instantly became high-temperature heat energy. Most of the Asteroid and impacted terrestrial rocks vaporized and exploded, scattering debris over a very wide area. Some of the Asteroid survived and buried itself deep underground. Some of the impacted rocks also survived. Together they melted into an underground 'magma pool' that remained molten for thousands of years before slowly cooling and solidifying into rock.

Impact magma, generated in the Crust below the impact site, extended a lobe to the east and north under present-day Washington, Iron, and Madison counties. Magma then underwent density differentiation (think Sudbury, Canada) and froze into mafic (rich in magnesium and iron minerals) rock with internal layers possibly enriched with iron, cobalt, copper, nickel, rare-earths, and other elements obtained from both local rocks and from the surviving Asteroid fragment.

Impact shock surged down through the thinner Precambrian Crust and into the underlying Asthenosphere upper Mantle zone starting just below the base of the Crust. Fractures created a permeability column through the Crust and upper Asthenosphere where gasses, liquids, and magma could travel upward. The fracture column penetrating the Crust and Asthenosphere opened a conduit of lower pressure that caused decompression melting in the Asthenosphere, creating mafic magma injected into the Crustal fracture column possibly as far upward as the annular fault around the impact crater. That set off the circulation of already metastable hot Mantle material, starting a Mantle Plume.

Mantle Plume circulation was a magma-generating conveyor bringing hotter, deeper Mantle material upward and into contact with the Crustal base, melting the lower and possibly middle Crust and mobilizing gasses, metals, and other rock components and propelling this material upward toward areas of lower temperature and pressure at the surface.

The Mantle Plume was relatively small, local, rootless, and short-lived, but powerful. Think of the Plume as an enormous geological welding torch aimed at the Crustal base.

Thus, began intrusion of Missouri Batholith granite that created the Missouri Gravity Low.

Unlike the Asteroid that killed the dinosaurs, this impact was not a megadeath event. There wasn't much to kill. No fish, no land animals, no land plants. Life had developed only in a water environment in oceans, rivers, and lakes, and only to the stage of Cyanobacteria, also called Blue-Green Algae. These would have been killed at the impact site and the surrounding area, but not everywhere worldwide. Algae are highly talented at reproduction and quickly repopulated the kill zone. Think about how fast algae grows in creeks and ponds as the weather warms at winter's end. *Ozarkcollenia* stromatolite algae fossils, with a distinctive laminated morphology, were discovered in an old manganese mine by Paleontologist Dr. Bruce Stinchcomb in Precambrian lake sediment Hot Spring limestone rock in bedded volcanic tuff on Cuthbertson Mountain near Arcadia in central Iron county. So we know algae were present. However, these particular algae fossils are in younger Precambrian volcanic rock, not in the Asteroid-impacted older Precambrian, pre-volcanic, gneiss, and schist.

There are no known Precambrian carbonate rocks in the manganese mine vicinity that could be the source of Calcium Carbonate, and certainly not of heat, in the hot spring water. The most likely source of both is a near-surface Precambrian active intrusion of

Carbonatite. Carbonatite fits within the overall local geological model that includes a skarn gold deposit, several nearby igneous iron deposits, and several positive gravity anomaly peaks.

So, if the Asteroid blasted out a crater tens of miles wide and miles deep, where is the crater now?

Hills and holes are temporary features. Mountains erode away. Holes fill up. The crater began to fill with sediment. Erosion during the following billion years washed away the crater and surrounding landscape. Volcanic eruptions and the deposition of marine sedimentary rocks covered everything that remained. There is nothing left to see. Remnant impact structure may be only a mile or two away -- but straight down!

ENTER PLATE TECTONICS

The topmost older Precambrian rock below the volcanic rock is gneiss (pronounced 'nice') and schist. You can see outcropping gneiss and schist (probably a large xenolith) in Hawn State Park east of Farmington in Sainte Genevieve county, along the Pickle Creek hiking trail upstream from the campground picnic shelter. These are metamorphic rocks created by heat and pressure from older rocks that could be of any type.

Erosion of much older rocks on a pre-volcanic Precambrian paleosurface may have created large, preserved placer deposits enriched with magnetite iron oxide and other dense and durable minerals including the rare-earths mineral monazite. These would have been covered and preserved once volcanic activity began.

Gneiss and schist themselves may have been metamorphosed from even older sedimentary rocks that contained preserved iron mineral placers and/or a type of globally widespread sedimentary iron deposit called Banded Iron Formation. Resident older iron deposits may have been mobilized by intruding Missouri Batholith magma and redeposited in younger Precambrian volcanic rocks to make Missouri's many igneous-related iron ore deposits. At any time during this long history, igneous activity itself could have created magmatic or hydrothermal iron deposits within any of the host rocks. This pattern could have continued for even more cycles in even older and deeper Missouri Precambrian rocks.

Since the Asteroid impact, tectonic plate motion within the North American continent moved the Crust and the enclosed impact structure 370 miles southeast along the Missouri Batholith trail, separating the Asteroid crustal impact structure now in southeastern Missouri from the Precambrian Nebraska impact-generated former Mantle Plume in the Asthenosphere uppermost part of the Mantle just below the base of the crust. A slight kink mid-trail reflects a change in direction of Plate movement.

Missouri's iron ores and iron mines in Precambrian rocks in the Washington and Iron Counties Iron District may owe their mineral wealth directly or indirectly to materials introduced by the asteroid. Enrichment of cobalt and nickel in Mississippi Valley-type lead ore deposits at Fredericktown and Mine Lamotte in the Madison county Cobalt District also may be a result of the asteroid.

Or not. How can we decide?

Depends on Asteroid composition.

There are two common types of Asteroids -- Metallic, and Chondrite. Metallic Asteroids are made of nickel and iron plus a smaller amount of other metals. Chondrite Asteroids are non-metallic rocks, although some metal may be present. Most Asteroids are Chondrites.

PEA RIDGE

James Kennedy, the owner of the Pea Ridge iron mine in northern Washington county, generously supplied archived samples of mine rock for analysis. The objective was to help identify the Asteroid's type - Iron/Nickel metallic, or stony Chondrite - by analysis of elements the Asteroid may or may not have introduced into impacted rocks. The decision depends on, primarily, do the mine rocks contain more Platinum Group metals than regional Precambrian volcanic host rocks surrounding the mine?

We also hoped for big numbers in the assay report that would suggest millions of dollars of recoverable Platinum Group metals in the Pea Ridge mine iron ore and tailings.

Selected samples were Magnetite iron ore, Pyrite, rhyolite host rock, and tailings. A sample of Breccia Pipe with high-level enrichment of many elements plus whole-percent rare-earths including the 'heavies' unfortunately was unavailable.

Samples were shipped to Activation Laboratories at Ancaster, Ontario, Canada, and analyzed for multiple elements by Inductively Coupled Plasma/Mass Spectrometry and Instrumental Neutron Activation. Platinum Group metals were assayed separately.

Mission accomplished. Data strongly suggest the Asteroid was a non-metallic, rocky Chondrite. No Platinum Group element concentrations of significance were found.

Bye-bye, the hoped for millions of Platinum Group byproduct dollars.

Here's what the analysis report shows.

Platinum Group Lower Detection Limits are Osmium 2 pp**B** (parts per **BILLION**), Iridium 0.1 ppb, Ruthenium 5 ppb, Rhodium 0.2 ppb, Platinum 5 ppb, Palladium 5 ppb.

Reported concentrations are Ruthenium: Magnetite 6 ppb, Pyrite 37 ppb, Apatite (tailings) 17 ppb.

Rhodium: Pyrite 0.3 ppb, Apatite (tailings) 0.2 ppb.

Palladium: Pyrite 3 ppb, Apatite (tailings) 2 ppb.

All others are less than the Lower Detection Limit. At reported ppB concentrations everything is essentially ZERO.

Nothing exciting in the other elements. Gold 15 ppb Pyrite, Arsenic maximum 46 pp**M** (parts per **MILLION**), Cobalt 1430 ppm, Iron 62.9% (it's Magnetite iron ore).

The geochemical analyses show no, or essentially no, Platinum Group metals.

Keep in mind that Pea Ridge mine rock samples represent magmatic fractionation of the host material and may present skewed results depending on Platinum Group partitioning between host rock, magma, hydrothermal components, and the resulting ore deposit of almost 100% Magnetite iron oxide. Other analyses from other areas and iron deposits are needed to extend Pea Ridge ore body results into a regional picture.

But for now, the Asteroid is shown to be a Chondrite that contributed lots of impact energy but little or no substance to southeast Missouri iron ore deposits, Cobalt District cobalt and nickel deposits, and uranium and thorium in granites.

Geochemical components of local volcanic and mine rocks, therefore, are homegrown and of planetary, not extraterrestrial, origin.

CLOSING THE FRACTURE COLUMN

As Mantle Plume heat continued melting older rocks of the lower and possibly middle Crust, Plate Tectonics slowly pushed overlying Crustal impact structure host rocks off of the underlying Asthenosphere Mantle Plume.

Early on, when Crater temperature had cooled sufficiently and clastic sediment was being deposited, life invaded the Crater lake. First extremophilic, then thermophilic, and then common organisms, mainly or entirely forms of algae, colonized lake water and bottom sediments. Preserved organic material accumulated in Crater sediment.

At first, Mantle Plume-mobilized gas and hydrothermal lower and middle Crustal material went directly up through the fracture column and saturated Crater sediments. The most mobile materials such as fluorine, hydrogen chloride, carbon dioxide, water, and uranium went first and deposited their mineral load in crater sediments.

Sometime later, slower-moving Missouri Batholith granite magma arrived. Magmatic heat cooked Crater sediment organic material into gas and oil, and then into asphalt and carbon, creating a strong chemically reducing environment in Crater sediments that caused increased deposition and retention of uranium, thorium, and other elements. Slower travelers such as iron oxide minerals followed.

Missouri Batholith magma continued rising through the impact structure's newly mineralized sandstone sediment and assimilated recently deposited uranium, thorium, potassium, and silica, formed cupolas, and erupted, starting the St. Francois Volcanic Province.

Graniteville Granite, the frozen magma chamber of a Precambrian volcano, is the surface rock at Elephant Rocks State Park in Iron county, and averages 16.9 ppm (parts per million) uranium and 42.6 ppm thorium. Nearby Butler Hill granite averages 6.2 ppm uranium and 42.6 ppm thorium. Breadtray Granite averages 5.6 ppm uranium and 20.5 ppm thorium. All three granites are above uranium and thorium background concentrations of other local granites. Elevated concentrations of uranium and thorium extend into volcanic rocks derived from these granites.

It may seem reasonable that Missouri Batholith magma intruding the impact Crater center might pass through and assimilate the most uranium and thorium. However, there are no granite or volcanic outcrops to test this in Carter county's high cancer region. There are outcrops of rhyolite in Reynolds county to the north and Wayne county to the east, that lie above the crater center, and certainly, there should be granite and rhyolite rocks at depth within and above the impact structure center in northeastern Carter county, but there may not be drill core or other available specimens to test for uranium and thorium.

During continuing Plate Tectonic movement toward the southeast, the Mantle Plume entry port for Crustal base fracture column decompression and granite magma and hydrothermal fluids moving into the impact structure was slowly shut off, as though by the closing of a gate valve, on the south side first, and on the north side last. Magma generated within the Crust by residual Mantle Plume heat was less immediately affected.

Hydrothermal activity powered by the Mantle Plume was progressively restricted southward in the Crater and redirected and concentrated northward. As Plate motion slowly closed the hydrothermal fluids entry port above the Mantle Plume, Crater fill on the north side got maximum exposure of time, volume, and concentration of upwelling hydrothermal fluids transporting metals and other materials. Northside crater fill sediments presumably received and retained the most total iron, uranium, thorium, rare-earths, and other materials that the rising Missouri Batholith magma would later assimilate.

The mid-north Crater area is where Graniteville, Butler Hill, and Breadtray granites enriched with uranium and thorium are located. That also is where the Pilot Knob and other iron ore deposits begin. The Pea Ridge area group of magnetite deposits with known and expected strongly mineralized breccia pipes occur still farther north at the north rim of the Crater.

It all fits.

VOLCANIC CHILI

Although volcanic landforms eroded away long ago, remnant volcanic structures in Precambrian rocks show where the volcanoes were.

Missouri volcanoes, in common with most volcanoes everywhere, built typical mound-shaped or cone-shaped landforms as magma welled up within the Impact Structure and erupted as ash and lava flows. Rising magma supported the volcano top. When magma flow stopped, support was lost, and the volcano top collapsed into the magma chamber along an approximately circular 'Ring Fault'. Collapse repressured the magma chamber and caused secondary magma intrusions and small eruptions. For a modern example see the section on Crater Lake, Oregon, later in this document.

Magma formed as the impact-initiated Mantle Plume was activated in the upper Asthenosphere. Secondary magma also formed where lower and middle Crust materials were melted by Mantle Plume heat. Magma moved up the fracture column into the upper Crust and erupted as volcanoes within the Impact Structure,

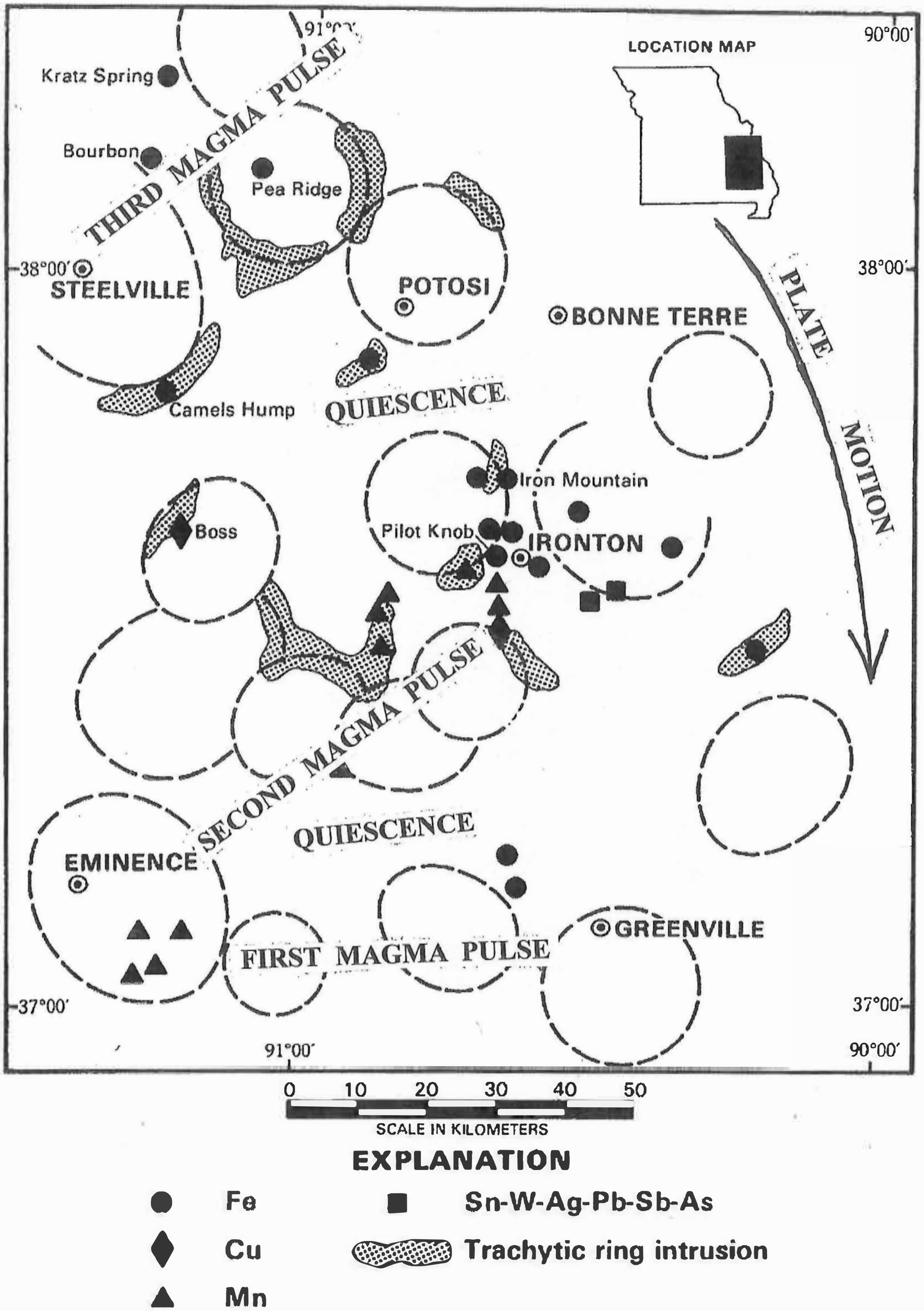
Seventeen remnant volcanic ring faults have been found in the Asteroid Impact structure as shown on the Ring Structures map from **Precambrian Geology And Ore Deposits Of The Southeast Missouri Iron Metallogenic Province** by Geza Kisvarsanyi and Eva Kisvarsanyi. I remember when I first saw that map. The pattern of volcanic structures reminded me of steam bubbles popping at the surface of a pot full of boiling chili.

If you back away enough that your viewpoint encompasses the entire system, the chili pot metaphor comes into clear focus.

- The kitchen stove = the Asthenosphere.
- Air in the kitchen = the Crust.
- The gas burner or other heat source = the Mantle Plume.
- Asteroid Impact Structure = the cooking pot.
- Beans and other ingredients = shattered rock in the fracture column.
- Physical and chemical changes of ingredients during cooking = rock alteration.
- Steam bubbles popping at the chili surface = volcanoes.
- The delicious odor of cooking chili = eruptions of gas from volcanoes.
- Crackers? No known equivalent.

The mapped ring faults occur in three clusters with trend axes rotating counter-clockwise from south to north across the map, reflecting the change in the direction of tectonic plate motion. The three clusters likely represent three large magma pulses separated by quiescence. Trend axes with a large east-west component, located between 37 and 38 degrees north, probably were influenced by, or even initiated, the proposed **38th Parallel Lineament** structure that today is marked by a string of ore deposits and structural features trending east-west across Mid-America at approximately 38 degrees north.

The first, southern magma intrusion, Eminence through Greenville, passed through freshly fractured rock with intact pre-impact physical properties and chemistry. This rock retained its original content of water and more mobile chemicals such as carbon dioxide, uranium, lithium, and halogens. These initial relocated materials tended to accumulate as greisen and pegmatite within resulting igneous rocks, particularly in Shannon county and along the border between Reynolds and Carter counties.



Ring structures, alkalic-intermediate rocks, and mineralization in mineralization in the St. Francois terrane, southeastern Missouri (adapted from Kisvarsanyi and Kisvarsanyi, 1981).

Adapted From: PRECAMBRIAN GEOLOGY AND ORE DEPOSITS OF THE SOUTHEAST MISSOURI IRON METALLOGENIC PROVINCE Geza Kisvarsanyi and Eva B. Kisvarsanyi , 1981

Circular Features Identify Precambrian Volcano Collapse Structures.

The second, middle magma intrusion, passing through the Ironton area, went through fracture column rock already somewhat depleted of easily relocated elements by the first magma intrusion. Along this trend, iron deposits were emplaced by a combination of hydrothermal and magmatic injection processes. At the Madison County Cobalt District at Fredericktown and Mine Lamotte, and across the Ozark Uplift at the center of the Viburnum mineral trend, Precambrian igneous rocks were enriched with cobalt and nickel that were later relocated into Mississippi Valley-type lead ore deposits in overlying Bonneterre formation dolomite.

Pegmatite and possibly greisen creation remained active at reduced intensity. The diabase dike on Mt. Devon west of Fredericktown contains large feldspar crystals chemically incompatible with the diabase host, but no fragments of pegmatite ***rock***, suggesting that the dike intruded a pegmatite under construction and incorporated feldspar crystals from the crystallizing magma. Similar rock that outcrops several miles farther west along Highway E suggests that a large pegmatite zone may exist at shallow depth.

The third, northern magma intrusion, was running low on water. Iron deposits in the Pea Ridge area tended more toward magmatic injection and less toward hydrothermal minerals deposition. The remaining water formed Breccia Pipes (pronounced Bret - chee - ah) that emplaced relatively small and rich concentrations of metallic minerals as vertical columns through iron ore at the Pea Ridge mine, including whole-percent concentrations of rare-earths minerals.

Asteroid impact influence may extend outside the impact structure. The Illinois Fluorite District in Hardin county, Illinois, is about 85 miles east of the impact structure's eastern rim. That is a bit over half of the impact structure radius and well within the zone of possible influence of Asteroid impact. Fluorite structurally associated with the volatiles-rich first Precambrian impact magma intrusion may have been the source of fluorite relocated into overlying Mississippian-age sedimentary rocks in the Fluorite District. Hicks Dome in southern Illinois is a Devonian uplift structure containing rare-earths and thorium possibly derived from magma associated with the Asteroid Impact and relocated from underlying Precambrian rock by the igneous intrusion that created Hicks Dome.

MISSOURI BATHOLITH, MISSOURI GRAVITY LOW, AND OLYMPIC DAM-TYPE IOCG EXPLORATION

The Impact Crater is in Crustal rock. As tectonic plate motion progressed and Crustal rock moved southward, the impact structure was progressively cut off from connection with the Mantle Plume and was completely detached after tectonic displacement reached impact structure width of ~125 miles.

After the connection was broken, the Mantle Plume no longer directly affected the Impact Crater but did continue pumping magma into the Crust. Igneous influence on Crustal rock became progressively less and igneous-related features shown on the Gravity map become wider, weaker, and 'fuzzier'.

Instead of forming a large ball of granite above the Mantle Plume, rising magma was strung out southeastward by Plate motion, like material being continuously deposited on a moving conveyor belt, leaving a trail of Missouri Batholith granite 370 miles long. The oldest granite is at the south end of the Crater. Granite is increasingly younger northward.

As Missouri Batholith granite magma intruded upward, high areas of magma called cupolas broke through to the surface and created Precambrian volcanoes of the multi-state St. Francois volcanic province.

This volcanic province feature is exposed in Iron and Madison counties but mostly buried elsewhere under younger sedimentary rocks. Lack of widespread exposure complicates geological study.

Elephant Rocks State Park near Ironton exposes frozen Graniteville Granite in the magma chamber below a Precambrian volcano.

GRAND RIVER TECTONIC ZONE (GRTZ)

The Grand River Tectonic Zone (GRTZ) is a right-lateral Continental Transform Fault on the east side of the Missouri Batholith, and similar to the San Andreas fault in California. A branch of GRTZ in Madison county shows 18 miles of right-lateral horizontal offset, moving rock formerly at Ironton into position south of Fredericktown.

GRTZ extends from the Reelfoot Rift in southeastern Missouri all the way through northwestern Missouri and on to join the Midcontinent Rift System at the southwest corner of Iowa. GRTZ is the eastern side of a graben developed over the Missouri Batholith.

MISSOURI BATHOLITH (MB) and MISSOURI GRAVITY LOW (MGL)

The 1.37 Ga (or younger) Missouri Batholith is 125 kilometers (77 miles) wide and 600 kilometers (372 miles) long, trends northwest across Missouri, continues to the intersection with the 1.0 Ga - 1.2 Ga Midcontinent Rift System, is made of granite, is 11 kilometers (about 8 miles) thick, and the top is about 5 kilometers (3 miles) below land surface. The northeast side of the batholith has a shallow dip of about 20 degrees and the southwest side a steeper dip of about 60 degrees.

The Missouri Batholith can be traced by its gravity signature known as the Missouri Gravity Low (MGL), a zone of gravity measurements lower than gravity measurements in surrounding areas.

PROBABLE IOCG ORE DEPOSITS

Heat from the Mantle Plume, heat from radioactivity of Missouri Batholith granite enriched with Uranium, Thorium, and Potassium, and Geothermal Gradient heat brought upward by fluids rising through deep conduits along GRTZ, kept hydrothermal activity going for a long time after the initial Missouri Batholith magmatic heat faded away.

Ongoing GRTZ fault activity from Precambrian time (1,500,000,000 years ago) to Pennsylvanian time (300,000,000 years ago) provided frequently renewed horizontal and deep vertical passageways for migration of gasses and hydrothermal liquids that caused mild regional alteration of Precambrian rocks. Rising hydrothermal fluids interacted with cold, oxygenated, descending meteoric water to create geochemical cells that deposited ore minerals in cavities produced and renewed by the ongoing, frequent fault motion along GRTZ.

Older Precambrian gneiss and schist were also altered but are too deep to be of importance to mining. However, the deeper Precambrian rocks served as a source of chemical elements hydrothermally relocated into overlying IOCG deposits.

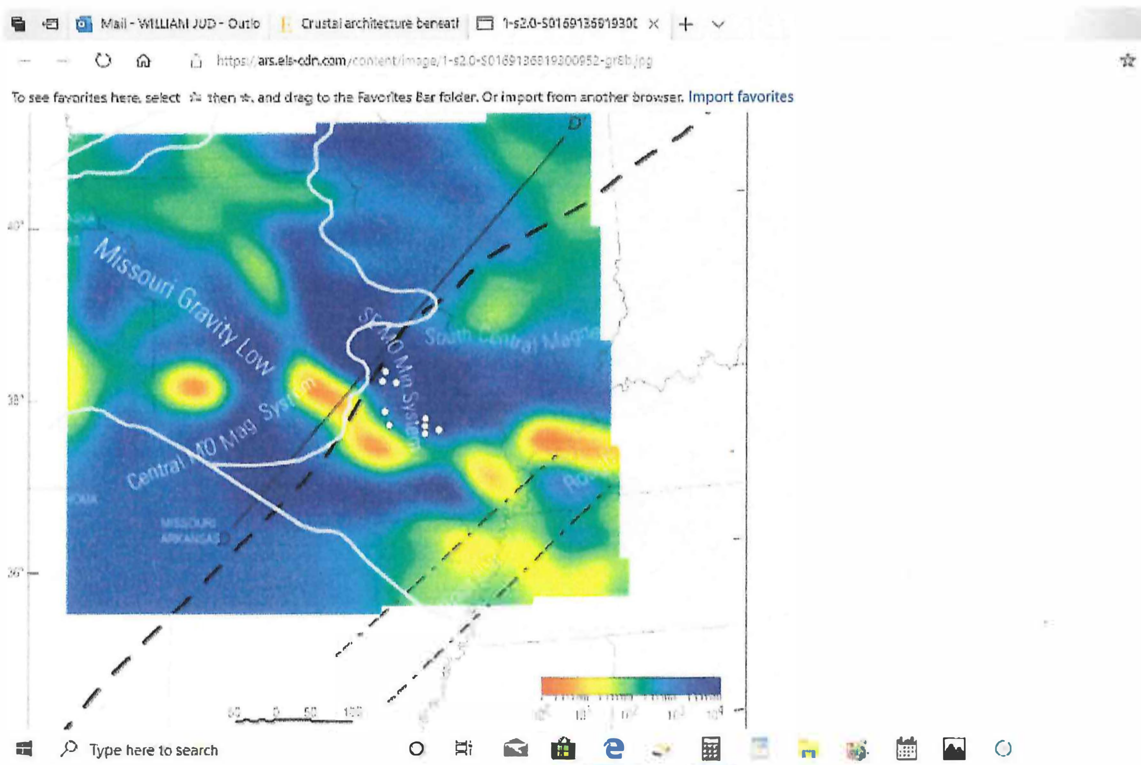
That's 1,200,000,000 years of ongoing geological and geochemical activity of the sort that creates Olympic Dam-type IOCG (Iron Oxide - Copper - Gold) ore deposits. These deposits usually are low grade and enormous. The namesake Olympic Dam ore deposit in South Australia contained over 4 billion tons of ore before mining began.

EARTHSCOPE MAGNETOTELLURIC SURVEY

A southern Missouri EarthScope magnetotelluric survey recently done by Anne McCafferty at the Denver US Geological Survey discovered a large electrically conductive zone at 26 miles depth in southeast Missouri. The conductive zone could be sulfide minerals or graphite. If sulfides, some of these could have been relocated upward by long-term hydrothermal activity along GRTZ to mineralize overlying Olympic Dam-type IOCG structures.

DEEP ZONE OF HIGH ELECTRICAL CONDUCTIVITY (YELLOW/ORANGE), PROBABLY GRAPHITE OR SULFIDE MINERALS

EARTHSCOPE MAGNETOTELLURIC SURVEY, ANNE McCAFFERTY, US GEOLOGICAL SURVEY.



Initial IOCG exploration looks for positive gravity and magnetic anomalies that are coincident or close together. The Pea Ridge magnetite ore deposit's magnetic signal is so strong that the deposit was first noticed by Highway Department surveyors who saw their magnetic compass deviate as their survey line passed near Pea Ridge. There likely are several more, similar IOCG ore deposits awaiting discovery in southeast Missouri.

Continuing GRTZ fault motion created and renewed multiple sites where warm, rising, mineralized hydrothermal fluids met and mixed with cold, oxygenated, descending meteoric water in geochemical cells under conditions favoring the creation of ore deposits.

As tectonic movement progressed, from time to time the Mantle Plume came into alignment with pre-existing iron deposits in older Precambrian gneiss and schist.

As mentioned, pre-existing iron enrichment had several possible sources, including pre-volcanic placer deposits, Banded Iron Formation, and igneous-related iron deposits. Iron relocated by hydrothermal and magmatic activity from old deposits in underlying gneiss and schist became younger Precambrian volcanic-hosted hematite and magnetite iron ore deposits now found in Iron and Washington counties and vicinity.

Olympic Dam-type ore deposits are known in southeast Missouri. Pea Ridge in northern Washington county and similar nearby Magnetite iron deposits are considered to be the 'roots' of Olympic Dam-type deposits from which overlying Olympic Dam-type replacement mineralization was removed by erosion.

Going southeast from Pea Ridge, Precambrian erosion cut less and less deeply into and removed less thickness of Precambrian rock. If Olympic Dam-type ore deposits ever existed to the southeast of Pea Ridge the deposits were not removed by erosion and remain to be discovered.

Expected primary IOCG mineral products include iron, copper, cobalt, nickel, gold, silver, rare-earths, uranium, and thorium. Faulted and brecciated host structure in GRTZ and low grade, very long term, geochemical activity causing mild regional rock alteration along GRTZ offer good hunting territory for discovery of several IOCG ore deposits.

As a bonus, conditions that create IOCG ore deposits likewise are favorable for the production of gemstones, especially topaz and amethyst, and for byproduct production of phosphorus (Apatite), fluorite, and barite. Possible raw material for fertilizer and jewelry industries.

Of particular interest is the intersection of GRTZ with PRECAMBRIAN faults including volcanic collapsed caldera ring faults where there may have been concentrated hydrothermal, groundwater, and brecciation activity.

Olympic Dam-type ore deposits are most likely to be found along long-lived crustal-scale faults such as GRTZ in brittle fractures, shear zones, rock formation contacts, high permeability aquifers, abrupt changes in vertical and/or horizontal aquifer channel direction, and zones of extensive rubble or shattered rock. GRTZ has these features.

Within clusters of known IOCG deposits in other areas such as South Australia, iron oxide deposits may form a trail up to 70 miles long and more than 10 miles wide, with individual deposits at intervals of 10 to 20 miles. Missouri's known Precambrian iron deposits occur in that pattern. Linear areas of iron deposits offer better prospecting than areas where iron deposits are scattered.

On the contour maps of element concentration at the end of this report, Manganese, Lead, and Zinc show highest concentration at contacts between intruding Missouri Batholith granite and adjacent gneiss/schist intruded country rock, within the Asteroid Impact structure and particularly along the outer rim. Copper contours don't show much of a pattern. Arsenic is actually lower over most of the contoured area of the batholith proper but higher along the outer Impact Structure rim at the contact between batholith granite and intruded country rock.

DIAMONDS BY THE TON

Do you remember the movies in which Superman squeezes a handful lump of coal into a diamond? And not just any old diamond. A completely clear and transparent, flawless, no impurities, highest 'D' grade, quarter-pound, small grapefruit size, already faceted and polished gem diamond.

Nice trick.

Okay, I'll allow Superman to handcraft diamonds. But popping out fully cut and polished D-grade diamonds pushes suspension of disbelief rather too far.

Actually, Superman's trick has a tenuous connection with reality. If conditions allowed, the proposed southeast Missouri Asteroid impact really could have performed conversion of graphite to diamond on a scale of thousands of tons.

Don't sell mining stock just yet. The diamonds would be deep, sand size, poor quality, useful only as abrasive, more expensive to produce than lab-created diamonds, located outside the pressure/temperature diamond stability field, and in host rock heated to 1,050 degrees Fahrenheit by the geothermal gradient.

Can't go there. Drill steel and construction steel would weaken, sag, and begin to melt. Explosives would burn or self-detonate. Human miners couldn't live and mining robots would fry. Rock that hot at that depth becomes plastic so shafts and tunnels would quickly squeeze shut. Even magma might start to form. The idea of deep mining thousands of tons of diamonds is only a geological curiosity.

It all depends on whether there was massive deep graphite in the right place when the Asteroid hit.

If the Magnetotelluric high conductivity zone is graphite, and in the right location relative to the Asteroid impact, and was in place before impact, the impact shock wave could have converted graphite into diamond on a massive scale.

An example of graphite/diamond conversion by Asteroid Impact is the Popigai impact structure in Siberia, northern Russia.

36,000,000 years ago, during the late Eocene epoch a Chondrite asteroid about 5 miles wide crashed into Siberia blasting out a crater 62 miles wide, smaller but otherwise similar to the proposed southeast Missouri Precambrian Impact Crater. Geophysical maps of the Popigai crater show low values of magnetism and low overall gravity with slightly higher gravity at the center. The crater floor is covered by frozen impact melt and rubble.

The preserved Popigai impact structure is at the surface and accessible. No guesswork required. Diamond content is confirmed. Almost all diamonds are 0.5 to 2 mm in diameter, too small for jewelry. None are gem quality.

The impact shock wave passed through Precambrian Archean graphite-garnet gneiss, instantly converting graphite flakes into diamond in a thin hemispherical shell starting at a radius 8.5 miles from the impact site where shock wave pressure and temperature had dropped enough to permit conversion of graphite into diamond. This single Siberian Asteroid Impact deposit is believed to contain a greater weight of diamonds than the total weight of all the diamonds in all the rest of the world's diamond deposits, combined.

Impact shock from the larger proposed southeast Missouri Asteroid's impact would have been stronger than at Popigai. High-intensity shock energy went farther due to the greater size of the Missouri Asteroid. If the Magnetotelluric survey electrical conductor is graphite, was in place and in the right location and depth before impact, and the shock wave carried the proper energy intensity when passing through the graphite, instant conversion of thousands of tons of graphite into diamond occurred. It is possible there also may have been some local graphitic gneiss that participated in diamond creation at the large hemispherical effective shock radius, escaped erosion, and still remains at or close to the Precambrian paleosurface. However, that surface is itself buried under a thick layer of younger volcanic and sedimentary rock.

Is there a massive deposit of diamonds under southeast Missouri? Will we ever know the answer? The rocks are deep and way beyond direct observation. Did any shock diamonds survive, maybe in the outer fringe of the Impact Crater? Possibly, but those diamonds and the entire Crater landform probably eroded and washed away a long time ago.

WHY SO FEW FOSSILS?

When the Cambrian sea came in, the future southeast Missouri was located at a temperate latitude.

The Cambrian sea was warm and shallow. Sea creatures had invented shells that usually make good fossils. The sea was teeming with life and the fossil record should be extensive and abundant. According to the observed sparse fossil record, that did not happen.

Not that fossils are entirely missing from southeast Missouri's Cambrian sedimentary rocks. They are just fewer than expected from a warm shallow sea environment. Why is that? Could a huge Precambrian Asteroid Immpact have been a part of the cause?

Yes.

Asteroid impact generated Rhyolitic volcanic activity. Rhyolite weathered to form marine sediments that created acidic (low pH) conditions on and within the seafloor. Seafloor sediments originating as volcanic weathering products also likely poisoned the seafloor with 'Heavy Metals' and other toxic materials.

Cambrian creatures that formed fossils were shelled benthonic types that lived on or within the seafloor. Those creatures normally build their shells from the Calcium Carbonate mineral Calcite. However, when Magnesium reaches a high enough concentration in the water, shell composition changes in part or completely to the other common Calcium Carbonate mineral Aragonite. A low population of fossil shells, and extensive rock strata of Dolomite, indicate a Cambrian sea environment rich in Magnesium. Where and from what did the Magnesium originate?

Aragonite shells are weaker and softer than Calcite shells, offering less protection from predators. Less protective shells mean fewer survivors that could fossilize.

Aragonite is less resistant than Calcite to destruction by acid. Dead Aragonite shells dissolve in weak acid that does not affect Calcite shells. Dissolved shells don't create fossils.

Before Cambrian marine Carbonate sediment deposition really got underway, exposed seafloor and exposed dry land in adjacent watersheds draining into the sea were made of Precambrian volcanic rocks that assimilated chemical elements while passing through Asteroid Impact Crater rock and the underlying fracture column.

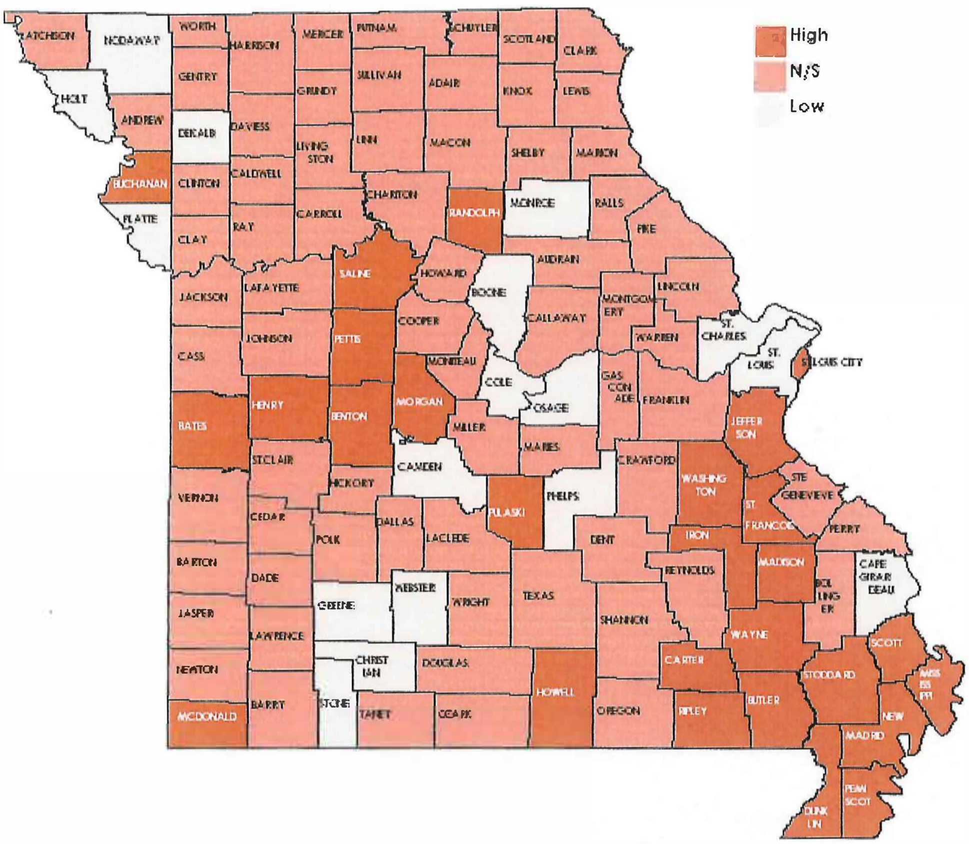
Some of those elements, such as Arsenic, locally may have been concentrated and abundant enough to be toxic to bottom dwellers living on or within seafloor volcanic rocks and their weathering-derived sandy sediments. Other elements, such as Copper, locally may have been concentrated and abundant enough to be toxic to algae, reducing the food available to grazing organisms at the bottom of the food chain. If the toxic metals existed as, or were associated with, sulfide minerals, weathering and oxidation would have generated an acidic environment in which toxic metals became even more concentrated in water and seafloor sediments and more biologically available.

Seawater moved enough to keep toxic materials flushed away and diluted poisonous elements that could have affected swimming organisms. But at the start of Cambrian time in southeast Missouri, there were few/no swimming organisms with shells that could fossilize.

Toxic local environments gradually faded away as marine limestone, shale, and Dolomite covered volcanic rock on the seafloor and the sea transgressed enough to extend carbonate rock sedimentary cover across and sequester volcanic rock in nearby watersheds draining directly into the sea.

CARTER COUNTY'S HIGH CANCER RATE

Maps and written information used in this section are used with permission of the Dent county, Missouri, SALEM NEWS, from the May 5, 2015 article by Andrew Sheeley titled **Ozark cancer rates among worst in nation.**



FROM THE SALEM NEWS:

To Dent county's south and east, 15 counties form an unbroken block (dark brown) of significantly high cancer death stretching from New Madrid county in the bootheel, all the way north to Jefferson county in metro St. Louis, and west to nearby Carter county.

Courtesy of Missouri Information for Community Assessment

Actions have consequences. Even the action of a big rock that fell out of the sky and crashed into the future Missouri ~1,500,000,000 years ago. The Asteroid Impact appears to be connected, although indirectly, with the regionally high cancer and kidney disease rate in southeastern Missouri and particularly in Carter county.

There are possible geological reasons for southeast Missouri's contiguous block of excess cancer death and the low population of fossils in area Cambrian marine sedimentary rocks. The reasons for both features include location above the south, east, and north position of the underlying Asteroid Impact Structure, coincident lead mineralization, and the extent of surface sandstone.

In brief, the Impact center under Carter, Reynolds, and Wayne Counties would likely contain the highest concentration and intensity of Crustal fractures in the fracture column connecting the older Precambrian Asteroid Impact paleosurface with the proposed Mantle Plume extending up to the Crust/Asthenosphere interface. The gravity map does show a ring structure of stronger gravity intensity surrounding the intersection of the three counties. The cause of stronger gravity could be a Peak Ring landform often found at the center of large impact craters, or it may be a Ring Intrusion of denser igneous rock.

If a Ring Intrusion, the introduction of exotic elements would be expected. Some of those elements can be toxic and/or carcinogenic, depending on circumstances.

There is no direct connection by which Crater material affects the modern surface. But Missouri Batholith granite magma erupting as volcanic material passed through fractured Crater rock before reaching the older Precambrian paleosurface, and assimilated elements along the way up. That geochemically enriched volcanic material is now the basal younger Precambrian paleosurface regional rock under and in direct contact with Cambrian marine sedimentary rocks that cover and underlie modern southeast Missouri. Toxic elements weathered from the volcanic rocks may have caused locally reduced populations of marine organisms and their subsequent fossils. If Cambrian marine life was locally affected by materials derived from volcanic rock, people living on the sedimentary rock above and vertically near that volcanic rock could also be affected.

IN HOT WATER

The introduction of lead ore adds complexity.

Although this varies depending upon whom you ask, Missouri's enormous lead deposits were created during mid to late Paleozoic or Mesozoic time or somewhat earlier when dinosaurs were stomping around what would become the Ozarks region.

Hot, salty, mineralized hydrothermal water intruded Missouri's basal Cambrian rocks, depositing lead, zinc, copper, cobalt, nickel, iron, sulfur, and small amounts of cadmium, silver, and uranium. Water temperature actually was not all that hot for a typical mineralizing hydrothermal fluid and was generally in the range of 75 to 200 degrees Centigrade.

Erosion was the dominant geological activity after Precambrian volcanoes shut down. Volcanic topography became rugged and hilly but no longer mountainous. Streams and rivers developed . Stream beds filled with locally sourced gravel, sand, and silt.

As all streams do, as stream channels went higher and higher up their watersheds, streams became smaller and smaller and finally faded away near the top. Going upward, streambed sediments changed from silt to sand to gravel and finally to boulders and then bare rock. You can see this pattern of upward coarsening in Ozarks streams today.

Stream channels were filled with younger Precambrian rock debris weathered from adjacent valley slopes of mostly volcanic rock. The volcanic rock was enriched with chemical elements acquired as Missouri Batholith magma passed through the Crater's central fracture column. Some enriched areas may have approached, or even been (and still may be), ore grade with respect to minerals containing iron, copper, cobalt, nickel, rare-earths, silver, gold, chromium, manganese, Platinum Group, and uranium.

Then the Cambrian sea moved in. Lamotte formation sandstone, part river sand, and part ocean sand, was the first sedimentary layer. Lamotte sandstone formed a blanket over Precambrian streambed sand and gravel and, as the invading sea deepened, continued to deposit upslope in the watersheds, but at many places stopped before reaching the top. That created what is called a 'Pinch-out' of sand against the hillside of Precambrian rock.

Then followed many more layers of marine limestone and dolomite, shale, and two more sandstones, the Gunter and Roubidoux (pronounced ROO - bid - doo). Sedimentation continued and additional rock formations were deposited upward. The higher formations, including St. Peter sandstone appear to have played little or no role in the processes under discussion here.

When metalliferous hydrothermal solutions later invaded, some of the fluids went deeply into, flowed through, and extracted elements from faults in the Impact Crater fracture column. Hydrothermal solutions also passed mainly through permeable weathering-derived volcanic sediments in paleostream channels cut into the Precambrian paleosurface, and less so through aquitards Lamotte sandstone and overlying Bonneterre formation carbonate rock above the channels. Chemical elements, including some possible exotics such as beryllium, uranium, and thallium scavenged from all three environments, dissolved and were transported along with elements originally present in the hydrothermal fluids.

Although salty and therefore usually denser than resident freshwater in the old river channels, the higher temperature of invading hydrothermal fluids resulted in overall density lower than the colder native groundwater. Sedimentary rock layers above the river channels were less permeable and therefore more confining than the stream sediments, effectively turning the channels into a pipeline confined between impermeable underlying and adjacent Precambrian volcanic rocks and overlying aquitard sedimentary rock layers.

Hot hydrothermal fluids less dense than cold native groundwater displaced groundwater and were driven by gravity up the river channels as far as permeability allowed. At the Lamotte sandstone pinch-out, the permeability pipeline ended. Rising hydrothermal fluids could not go higher so they spread sideways.

At many locations, Bonneterre formation limestone/dolomite carbonate rock was what the fluids spreading sideways went into. Fluid cooling, and chemical reaction of acidic hydrothermal fluids with carbonate minerals in the Bonneterre formation, caused the deposition of lead, zinc, copper, cobalt, nickel, and iron sulfide minerals that created Missouri's massive deposits of lead ore.

But hydrothermal water did not then simply vanish into a Black Hole.

The spent solution, now depleted of lead-related elements but still containing uranium, flowed on for many miles around and above the ore deposits, dissolving some materials from host rocks and depositing some materials at other places. Lead ore deposits typically are surrounded by a wide horizontal and vertical zone in which the rocks have abundant small holes known as 'vugs', a fraction of an inch to several inches in size and lined with agate that terminates inward as a layer of sparkly quartz crystals. Vug size and population are biggest adjacent to the lead ore and become fewer and smaller with increasing distance from the ore body, which is useful as a rough indicator of ore mineralization proximity. This geochemical activity continued well past the outer limit of ore deposits.

ACUTE vs CHRONIC

So, besides quartz, what might have the spent hydrothermal solutions have added, removed, or changed in local host rocks? Could those materials, in small enough concentration to escape notice, be a factor in high cancer and kidney disease rates? Possibly. Particularly with chronic exposure to uranium.

Rules are different for the health effects of acute and chronic exposure. 'Acute' is today. 'Chronic' is tens of years, essentially a lifetime.

For example. There is almost a 100% chance that you will have no lasting health problem if your lunch today is a triple bacon cheeseburger, double order of fries with ketchup, a quart of high-sugar carbonated soda, and pie with a big scoop of full-fat ice cream. You likely will regret it for a few hours afterward, but you will survive. That's

'Acute'.

However. If you eat that same amount of that same food every day, seven days a week, for 30 years, your chance of early death or at least severe health issues rises dramatically. That's 'Chronic'.

Environmental excesses or deficiencies of required nutritional trace elements often cause problems. Whether the exposure is acute or chronic also is important.

Livestock ranchers are usually aware of and deal with such trace element problems. At least the successful ranchers do that.

For example, selenium is a required trace element nutrient. Too little selenium in pasture soil can cause mastitis and calf scours in cattle. Too much ingested selenium can retard growth or cause outright poisoning.

Cobalt is a required trace element for cattle. Cobalt is used by rumen bacteria to make vitamin B12 (cyanocobalamin) which assists energy production and both weight gain in beef cattle and milk production in dairy cattle. In horses, too much ingested cobalt can cause problems with reproduction, weakened heart, thyroid failure, and cancer.

Uranium and uranium's radioactive products radium and radon at low concentration can cause kidney disease and cancer in people during chronic environmental exposure.

The problem may be synergistic, not excess or deficiency. Humans need to eat trace amounts of both copper and zinc to support many functions including defense against disease, wound healing, and carbohydrate metabolism. Copper is needed for blood, energy, strong bones, and heart health. But zinc in excess suppresses copper, effectively causing a copper deficiency even when dietary copper is adequate.

The problem may not be what is there but in what form. For example, trivalent chromium is required for the proper regulation of blood sugar. Hexavalent chromium is a poison. Same element, different oxidation states.

Some elements have no beneficial effect in humans, such as polonium 210, an isotope produced by radioactive decay of uranium 238. Polonium 210 emits energetic Alpha radiation, generally harmless outside the body but very harmful on the inside. Some plants such as Tobacco accumulate polonium 210 which is one of the harmful ingredients in tobacco smoke.

POPULATION TURNOVER

From a statistical viewpoint, the turnover of people living in the study area is a problem that makes identification of disease clusters more difficult. People moving in and out of the study area, children growing up and leaving home for careers in distant areas, and similar population mobilities that disturb the data base all contribute to a degree of uncertainty in epidemiological study results. A CHRONIC health problem must include long-term exposure to the cause to be accurately identified.

From a strictly statistical perspective, the perfect population to study would include young people who remained in the same house to age 110, their children to at least the fourth generation who moved no farther that 500 feet from their parents' house, and nobody moved in or out of the study area for at least 200 years.

That's not reality, of course. Disease statistics that include population turnover tend to underreport the cause and source of a health problem. If a chronic health problem that may require decades to appear in a mobile population is big enough to appear in a statistical survey done today, it is safe to assume that the health problem actually may be worse than it appears. Keep that in mind.when interpreting results of current epidemiological surveys.

GOLDILOCKS ZONE

The goal is staying in the so-called Goldilocks Zone. Not too much. Not too little. Just Right! This is a reference to Goldilocks' adventure in the story GOLDILOCKS AND THE THREE BEARS.

In the case of the high-cancer zone including Carter county and much of the rest of southeastern Missouri, is there a geochemical Goldilocks Zone? If there is, where and what is the Goldilocks Zone, how do we find out, and what if anything can be done to support human and animal health in the rest of the area?

EXPLORING FOR CANCER

Geologists often use geochemical surveys when exploring for minerals. Most ore deposits have a core of some desired mineral and a larger surrounding area of Pathfinder Elements associated with the desired mineral and providing a larger target for exploration.

The geochemical survey process used for minerals exploration can be used to determine a possible geological connection with regional cancer hot spots.

Obviously contaminated sites such as old industrial dumps don't need a geochemical survey to be found. These are commonly Superfund sites and have been known for many years.

Chronic, low-intensity problem sites can be of natural origin in relatively pristine places such as Carter and adjacent counties and normally do not exhibit the classic signs of contamination. However, low-intensity chronic exposure can badly affect the long-term health of residents. We just don't yet know if those places actually exist, whether there is a geological reason for the high rate of cancer, where those places may be in southeast Missouri, and why living there is unhealthful in the long term. But there are clues.

And if we don't yet know the cause, we don't yet know a possible cure.

Outcropping Roubidoux sandstone covers 52% of Carter county's surface. Roubidoux sandstone typically is an aquifer with limited ability to transmit and produce water. Many domestic water wells in Carter county use Roubidoux sandstone as the source of water -- obvious if Roubidoux sandstone is the surface rock formation for just over half of the county.

Roubidoux sandstone is made of grains of quartz sand. Chemically, quartz sandstone contains water that normally is acidic -- pH <7. Acidic water dissolves and transports metals present in local rocks. In extreme cases, naturally acidic groundwater can dissolve copper and iron from metal plumbing pipes and leave a blue copper stain or brown iron stain on a white porcelain surface where the water drips. Tastes bad, too.

This is in contrast with limestone/dolomite carbonate rock aquifers that tend to have 'hard' water carrying dissolved calcium and magnesium carbonates that deposit a white coating inside a pot when the water is boiled. Chemically, groundwater in a carbonate environment is alkaline -- pH>7. An alkaline environment neutralizes acid and suppresses dissolving and transport of metals by groundwater.

A cementation strength test to estimate sandstone permeability should accompany any geochemical test. Sandstone in which sand grains are weakly cemented together and there is some unfilled space between the grains tends to be an aquifer. Sandstone, called Quartzite, in which sand grains are strongly cemented together with no open space between sand grains has no permeability and is not an aquifer.

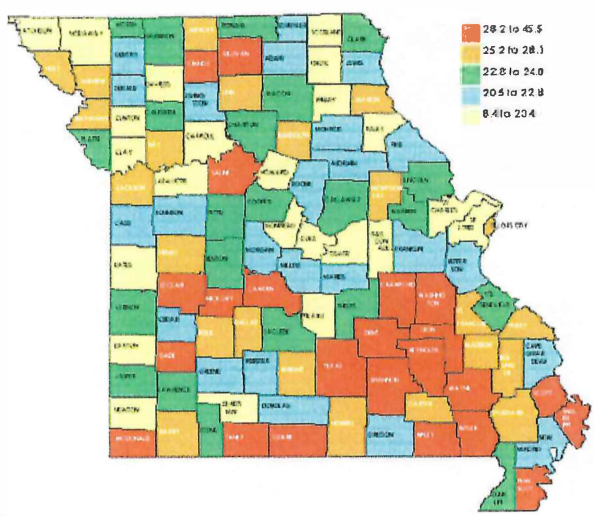
A simple test shows cementation strength. Put on your safety glasses and use your geologist's hammer to whack off a sandstone specimen. Use a pocket hand lens magnifier to examine the sample. If the broken surface goes around the sand grains, not across the grains, the rock is weakly cemented sandstone with some open space between grains and probably transmits groundwater. If the broken surface cuts across the sand grains, cementation is strong, and there is no open space between grains, the rock is Quartzite, and does not transmit groundwater.

There may be a mappable pattern of sandstone/quartzite that relates to mineralization derived from the nearby hidden hydrothermal emplacement of lead ore. If so, that information is valuable for both mineral exploration geologists and cancer hunters doing a geochemical mapping project.

Manganese accretion is another common occurrence within sandstone. In an oxidizing, surface environment, black manganese oxide can accumulate on sand grains. Manganese oxide is a scavenger that extracts and holds other metals present in groundwater. Some of those metals can be toxic. Plants growing on that sandstone extract and further concentrate some of those metals and pass the metals up the food chain to grazing animals such as rabbits, deer, and cattle, that further concentrate and pass the metals on to people and other carnivores that eat the grazers.

Long-lived carnivores such as people accumulate those toxic metals, possibly to the extent of causing cancer and other diseases after many years. That is a potential path today to chronic illness decades in the future.

RING AROUND THE IMPACT STRUCTURE.



SMOKING RATES.

Salem News article:

"Carter county's smoking rate is less than all of its neighbors but one. Yet its lung cancer rate is on average 48 points higher."

Courtesy of the Missouri Department of Health and Senior Services.

Coincidence does not prove cause but does raise an alert that something unusual may be present.

SMOKING

Two factors seem obvious from the initial examination.

A significant fraction of southeast Missouri's cancer is self-inflicted by smoking and other personal tobacco use, generally accompanied by other unhealthful habits. Smoking and environmental factors can be synergistic. The combination can be more than the sum of individual effects.

SANDSTONE

Surface sandstone and natural geological materials contained therein are the other suspects. Not sandstone itself, but materials carried in groundwater within the sandstone.

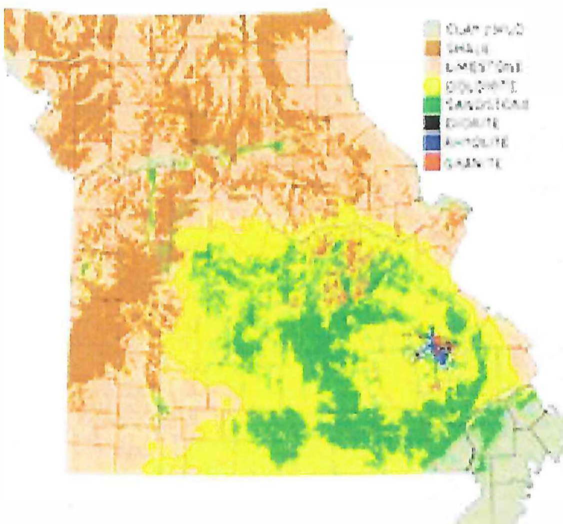
Sandstone's contribution is illustrated by the difference in cancer rates reported for Carter, Reynolds, and Wayne Counties at the center of the proposed Asteroid impact structure.

The Salem News article reports: "From a national perspective, Carter county's rate is so large it comes in as the sixth-worst county for cancer deaths in the United States for 2007-2011, according to State Cancer Profiles.

That's number six out of a total of 3,144 counties and county-equivalents in the entire USA."

Wayne County, the next county east of Carter, is part of the trend of high cancer rates extending along the east side of Missouri from the Bootheel to St. Louis. Reynolds County, the next county north of Carter, has a much lower cancer death rate.

<u>SURFACE GEOLOGIC ROCK FORMATION TYPES IN MISSOURI. SANDSTONE IS SHOWN AS GREEN.</u>



Carter county's surface is 52% Roubidoux sandstone, 47% dolomite, and 0.5% Precambrian igneous rock.

Wayne county's surface is 43% Roubidoux sandstone, 49% dolomite, and 2% Precambrian igneous rock.

Reynolds county's surface is 0.7% Roubidoux sandstone, 96% dolomite, and 4% Precambrian igneous rock.

Do you see a trend?

Reynolds county's smoking rate is higher than the smoking rate in Carter and Wayne counties, but Reynolds county has a lower cancer death rate. Half of Carter and Wayne counties' surface is Roubidoux sandstone. Reynolds county has essentially zero surface sandstone. Pretty good evidence for the influence of surface sandstone on cancer rate.

Geochemistry gets complicated along the trend of higher cancer from the Bootheel to St. Louis, the counties shown in dark brown on the cancer incidence map.

That area generally follows the east side of the proposed Asteroid Impact Structure. That's the same area where hydrothermal fluids invaded Cambrian rock formations and created Missouri's world-class deposits of lead and zinc ore. Farther north, in Washington county, hydrothermal fluids left large barite (barium sulfate) deposits along with significant lead.

And midway, in Madson, St. Francois, Bollinger, Cape Girardeau, and Perry counties, Mesozoic igneous and tectonic activity included extensive faulting, igneous intrusions, another batch of invading hydrothermal fluids, and limited volcanic eruptions. Fluids from the Reelfoot Rift backflushed through GRTZ as far west as Madison county (Fredericktown), deposited new minerals, and relocated some existing minerals.

That's a lot of geological confusion to untangle and a major additional source of possibly carcinogenic major and trace elements.

Continuing counterclockwise around the Asteroid Impact circle, and except for Pulaski and Howell Counties, surface sandstone on the northwest, west, and southwest sides does not coincide with high cancer rates, regardless of the smoking rate. This western side of the Impact circle also is generally outside of the zone of major lead mineralization.

BETTER GEOCHEMICAL MAPPING NEEDED

Some geochemical survey work has been done and results are published. Unfortunately, elements are reported as the Average (Statistical Mean) with only a single number for each county. That gives an extremely low-resolution picture of the geochemical condition. For example, geochemical surface soil lead in Carter county is listed as Average 175 ppm, Minimum 10 ppm, Maximum1,094 ppm. Zinc Average 274 ppm, Minimum 20 ppm, Maximum 1,718 ppm. No sample site locations are given. No data on the number of sample sites.

Although this information is a start, much higher density of sample sites is needed for meaningful results. A minimum of 2,000 sites is needed in each county, at least 4 per square mile, with locations reported. Much of the work may already be done but not reported.

At reconnaissance level, Carter county's 509 square miles might be adequately surveyed by 2,036 geochemical soil sampling stations, 4 per square mile, a half-mile apart, and on gridded locations. As 'hot spot' cancer concentration areas emerge in the epidemiological survey data, overall geochemical sampling area might be reduced and sampling in 'hot spot' areas increased in density and number of samples. In the case of small residential surveys of a square mile or less, Alpha Track radon cup surveys may be useful for mapping radon, but this requires two field visits and is weather sensitive and in-ground residence time sensitive, more of a nuisance than a problem.

In addition to the geochemical sampling of surface soil and rocks, I suggest Soil Gas Hydrocarbons (SGH) sampling, a technique developed by Dale Sutherland (now retired) at Activation Laboratories in Ancaster, Ontario, Canada. SGH, officially named "3D-Spatiotemporal Geochemical Hydrocarbons," is used by geologists to explore for oil and minerals and adds the vertical dimension of depth to data from geochemical mapping of surface materials, effective in some conditions down to 3,000+ feet depth. SGH may find and define potential Pathfinder Elements associated with carcinogens in bedrock from which surface soil was formed. SGH examines 162 hydrocarbon compounds in the C5-C17 carbon series range and can use a portion of the same soil samples collected for other geochemical survey work.

When done correctly, SGH can indicate depth to a mineral deposit and location of a buried mineral deposit. Is your land above, just near, or far away from a uranium deposit? Downstream from a uranium deposit along groundwater flow? This information is useful for both minerals exploration and for mapping carcinogenic uranium mineralization concentrations in aquifers.

In the study area, the same SGH data also could be used to find and map buried IOCG (Iron Oxide-Copper-Gold), Nickel (and Cobalt by association), Uranium, and Lithium Pegmatite, mineral deposits.

Fun Activity: If your memory of high school chemistry is foggy and you want a quick refresher of chemical element names, go on the Internet and download the novelty song THE ELEMENTS by Tom Lehrer. Does not include recent additions to the Periodic Table after the song was composed.

AVERAGE (MEAN) CONCENTRATIONS OF ELEMENTS BY COUNTY IN ASTEROID IMPACT STUDY AREA, SOUTHEAST MISSOURI .

National Geochemical Survey database (/geochem/)
Mineral Resources (https://minerals.usgs.gov/) / Online Spatial Data (/)

ppm = parts per million   % = weight %
SS = surface % sandstone. L = Lamotte, R = Roubidoux, P = St. Peter

COUNTY	As	Cu	Fe	Hg	Mg	Mn	P	Pb	Sc	Zn	SS
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	S%
BOLLINGER	7.6	10.4	1.6	0.03	0.25	899	0.03	22.4	0.28	41.9	R26P1
BUTLER	8.8	11.5	1.7	0.04	0.21	653	0.03	36.7	0.34	68.9	R36
C. GRDO	6.4	10.5	1.7	0.03	0.26	1002	0.04	19.2	0.18	43.2	P17
CARTER	7.5	13.9	1.4	0.03	0.2	918	0.02	113. 0	0.24	178.5	R52
CRAWFORD	5.4	13.1	1.3	0.03	0.4	560	0.02	67.2	0.22	69.7	R29
DENT	4.4	7.6	1.1	0.02	0.3	583	0.02	18.2	0.17	25.6	R44
DOUGLAS	10.8	12.1	1.5	0.02	0.7	589	0.02	27.0	0.22	54.6	R35
DUNKLIN	15.1	14.6	2.5	0.06	0.4	961	0.12	27.7	0.53	76.7	NONE
FRANKLIN	6.6	11.5	1.5	0.02	0.7	1137	0.04	28.2	0.18	72.7	R22,P1
GASCONADE	7.7	10.9	1.7	0.01	0.5	1298	0.4	17.2	0.15	27.2	R12,P2
HOWELL	12.1	10.0	1.9	0.03	0.2	694	0.3	33.1	0.27	84.3	R15
IRON	6.9	12.8	1.7	0.03	0.4	807	0.02	43.0	0.18	54.9	L1
JEFFERSON	6.3	13.9	1.4	0.02	1.1	911	0.04	71.9	0.23	111.8	R5,P1

ppm = parts per million   % = weight %
SS = surface % sandstone. L = Lamotte, R = Roubidoux, P = St. Peter

COUNTY	As	Cu	Fe	Hg	Mg	Mn	P	Pb	Se	Zn	SS
LACLEDE	6.6	16.2	1 .9	0.03	0.6	1010	0.04	23.2	0.27	42.3	R51
MADISON	7.4	12.9	1.9	0.03	0.4	1010	0.03	55.5	0.23	47.7	L5
MARIES	4.7	6.8	1.1	0.01	0.4	515	0.02	10.7	0.11	23.6	R22
MISSISSIPPI	9.1	17.0	2.5	0.05	0.5	1035	0.07	77.8	0.40	83.6	NONE
NEW MADRID	8.6	11.3	2.1	0.03	0.4	1093	0.07	20.2	0.29	77.4	NONE
OREGON	7.4	7.3	1.7	0.03	0.2	902	0.03	26.1	0.27	51.5	R35
OZARK	14.5	8.5	1.7	0.1	0.5	549	0.02	30.9	0.17	79.6	R15
PEMISCOT	13.1	15.9	2.8	0.05	0.6	595	0.10	30.1	0.72	127.5	None
PERRY	7.3	10.5	1.9	0.03	0.5	828	0.04	22.8	0.23	64.7	R7,P10
PHELPS	3.7	6.6	1.1	0.02	0.4	551	0.02	16.8	0.15	27.7	R48
PULASKI	3.8	7.0	1,2	0.02	0.5	612	0. 02	16.3	0.15	27.0	R44
REYNOLDS	5.3	16.8	1.1	0.03	0.3	930	0.02	22.0	0.21	35.9	R0.7
RIPLEY	9.6	7.0	1.8	0.04	0.2	836	0.03	32.6	0.34	54.4	R42
ST. FRANCOIS	7.7	21.3	2.0	0.03	1.3	1223	0.03	193.0	0.21	142.2	R1,L11
STE. GEN	6.2	12.2	1.6	0.03	0.6	887	0.04	36.2	0.21	42.	L18,R7,P4
SCOTT	6.4	6.3	1.9	0.02	0.3	886	0.05	28.8	0.16	41.9	P8
SHANON	7.5	16.2	1.5	0.04	0.6	1014	0.03	21.9	0.34	42.5	R41
STODDARD	6.9	6.7	1.7	0.02	0.2	864	0.04	20.9	0.23	39.8	NONE
TEXAS	7.5	9.1	1.5	0.03	0.6	693	0.03	18.9	0.28	30.4	R33
WASH	8.7	14.9	1.7	0.04	0.9	742	0.02	159.1	0.21	206.7	L1, R8
WAYNE	6.2	8.0	1.6	0.03	0.2	818	0.02	39.2	0.23	63.6	R43
WRIGHT	10.3	16.4	2.0	0.04	1.1	1004	0.05	26.5	0.49	45.1	R14

THERE ARE THREE LIKELY SOURCES AND MEANS OF ENVIRONMENTAL URANIUM INTRODUCTION IN SOUTHEASTERN MISSOURI.

There are three likely **sources** of environmental uranium in southeastern Missouri and in Carter county and vicinity in particular.

- Direct leaching into the groundwater of uranium from regional Precambrian intrusive and volcanic rocks enriched with uranium.
- Leaching of concentrated uranium from local Precambrian Pegmatite and/or Greisen.
- The possible contribution of uranium leached from the Chattanooga shale and from the Love Hollow rare-earths/phosphate formation in Arkansas and Illinois by hydrothermal fluids that brought in the big lead deposits.

And three likely **means** of redistributing and redepositing uranium.

- Uranium from the regional geochemical background and existing uranium deposits was introduced into Roubidoux (and Gunter?) and Lamotte sandstone formations by accompanying the hydrothermal fluids that created lead deposits.
- Destruction, mobilization, and redeposition of sandstone uranium deposits are now happening as Roubidoux formation sandstone erodes.
- Redox chemical deposition of uranium deposits from bat guano leachate and Athabasca-model geology.

A BRIEF GEOLOGY LESSON FOR NON-GEOLOGISTS

CRATER LAKE NATIONAL PARK, OREGON.

MT. MAZAMA VOLCANIC COLLAPSE CALDERA WITH SECONDARY ERUPTION OF WIZARD ISLAND VOLCANO.

About 7,700 years ago the Oregon volcano Mount Mazama had a major eruption that caused the top of the volcano to collapse into the underlying MAGMA CHAMBER. Magma was re-pressurized by the weight of the collapsing rock and had a small secondary eruption that created Wizard Island, the small island in the lake.

In Precambrian time more than a billion years ago there were several large Missouri Ozarks volcanoes that erupted in the Mount Mazama pattern.

Rising magma erupted as volcanoes. Magmatic pressure initially supported the volcanic summits. When the magma supply ran out the summits collapsed, forming approximately circular CALDERAS enclosed by RING FAULTS. At many locations, dikes and secondary eruptions occurred.

Those volcanic features remain today in southeastern Missouri's Precambrian-age rocks. Erosion removed the volcanic landforms, exposing deeper levels of the eruptive structures. Elephant Rocks State Park displays red Graniteville Granite that is the frozen magma chamber below a Precambrian volcano.

MAGMA FRACTIONATION, PEGMATITE, and GREISEN

Magma can be considered as melted rock rising from deep within the Earth. When the magma supply stops moving upward, molten material cools and starts crystallizing into hard rock. In the Ozarks, much of that rock is Granite composed mainly of Quartz and Feldspar.

As rock crystals grow in the cooling magma the crystals assimilate chemical elements needed to form their crystal structures. In Ozarks granites, those chemical elements are mainly silicon, oxygen, aluminum, and potassium.

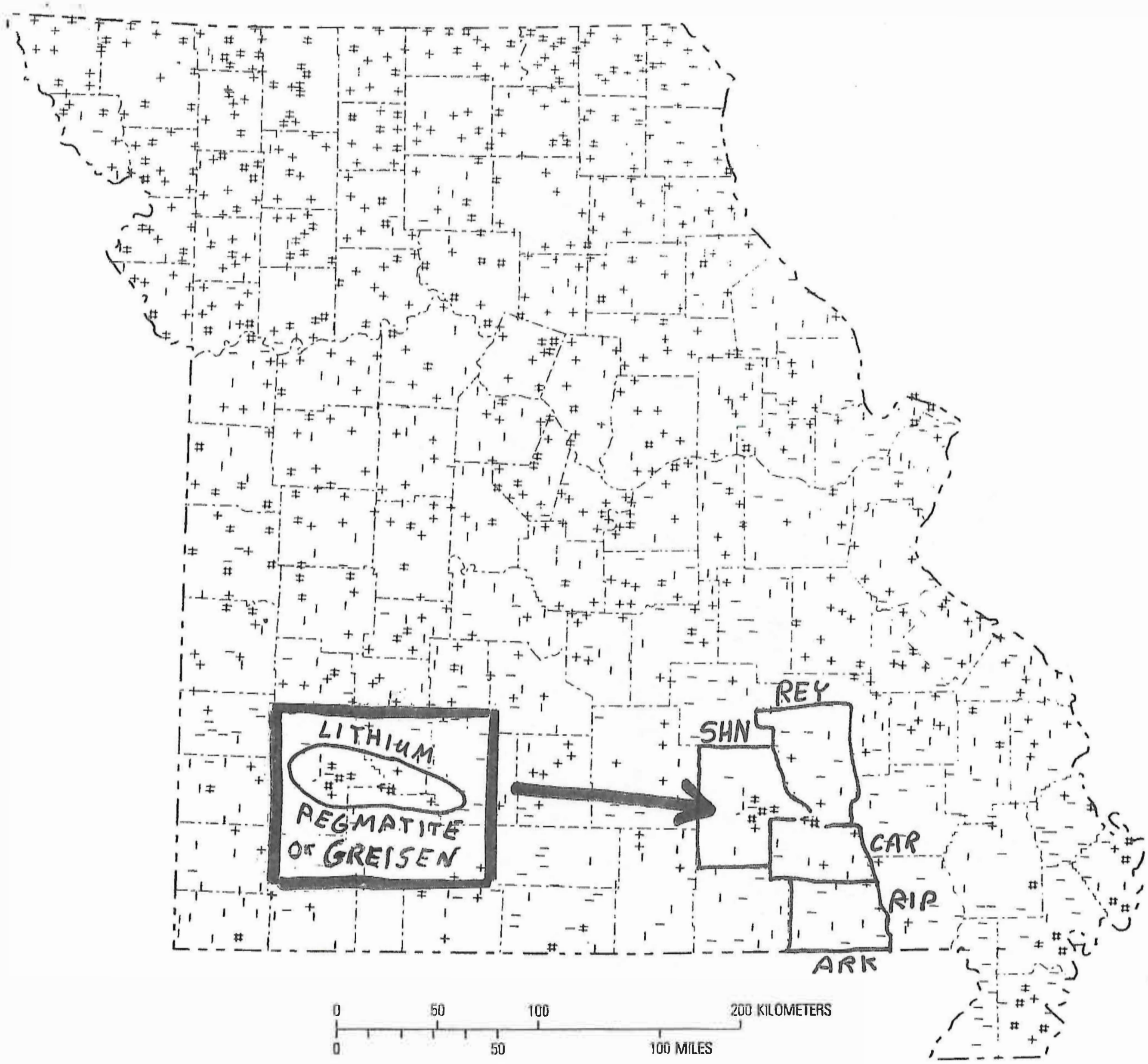
Magma contains other chemical elements that do not fit into the structure of the growing rock crystals. Those unused elements accumulate with water and other fluids in a residual fraction of magma.

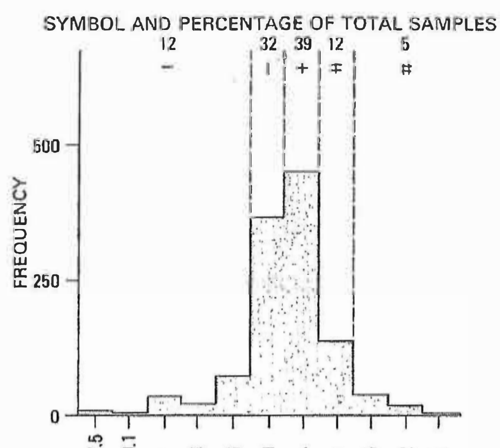
If the fractionation process continues long enough, the mass of rejected elements can become large and reactive, eventually forming separate deposits of exotic minerals. This generally happens as PEGMATITES form within voids in the newly created solid rock, and/or as GREISEN (pronounced GRY sen) forms near the top of the newly created igneous rock where remaining magma is sealed off from further upward movement by a cap of newly formed solid rock above. In these environments, exotic elements such as lithium, uranium, rare-earths, gold, beryllium, halogens, and others, may accumulate and form ore deposits.

DOWNLOAD THIS FREE REFERENCE DOCUMENT

US G E 0 L 0 G I CAL SURVEY P R 0 FE S S I 0 N A L PAPER 9 54 -H, I (1984)
A study of the distribution of 43 elements in agricultural soils at 1,140 locations in Missouri.
Geochemical Survey of Missouri.
Geography of Soil Geochemistry of Missouri Agricultural Soils.
By RONALD R. TIDBALL

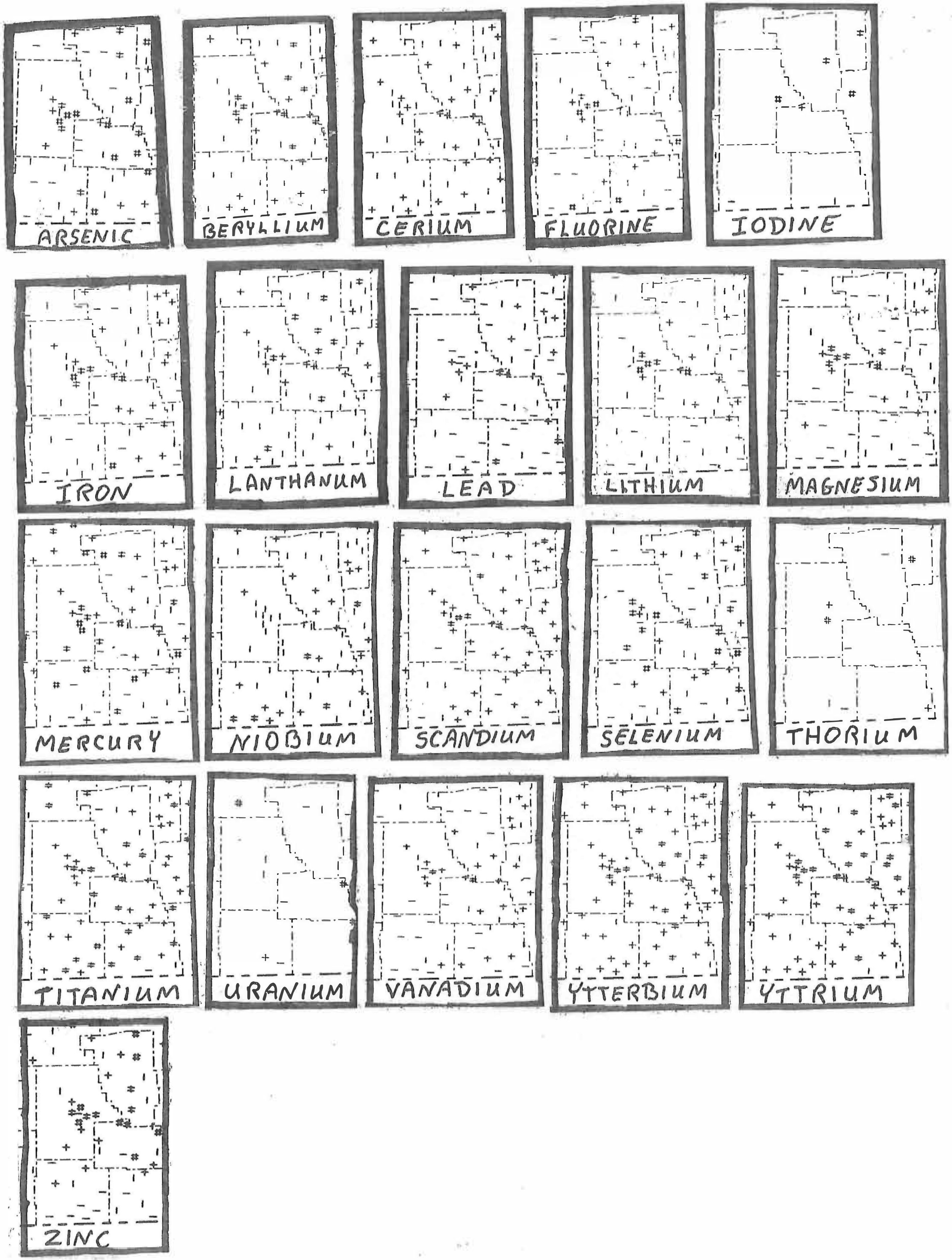
This US Geological Survey document presents a series of maps displaying statistical concentrations of selected chemical elements in AGRICULTURAL soil throughout Missouri.





Geometric mean 22
Geometric deviation 1.28
Analytical error variance
(percent of total variance) 4
Number of analyses 1140

FIGURE 20.—Lithium distribution in selected agricultural soils of Missouri. Map symbols correspond to frequency classes as shown in the histogram.


ARSENIC
BERYLLIUM
CERIUM
FLUORINE
IODINE
IRON
LANTHANUM
LEAD
LITHIUM
MAGNESIUM
MERCURY
NIOBIUM
SCANDIUM
SELENIUM
THORIUM
TITANIUM
URANIUM
VANADIUM
YTTERBIUM
YTTRIUM
ZINC

While helpful, reporting only on Agricultural soil in areas of limited agriculture such as Shannon, Reynolds, Carter, Wayne, and Ripley Counties eliminates much land area from testing and reduces the overall usefulness of the study. Reporting as statistical concentration instead of contoured data is a further restriction on usefulness for the purposes of the proposed research with regard to minerals exploration and the probable geological influence on Cancer and Kidney Disease.

Regardless, this USGS Professional Paper is a guide to underground geology as reflected in surface soil chemistry and is a useful although somewhat incomplete resource. The LITHIUM map is the base map used herein, and cutouts of individual element maps are provided for the Shannon, Reynolds, Carter, and Ripley Counties study area.

The important information is the coincident clusters of high concentrations of elements in soils of Shannon, Reynolds, Ripley, and Carter Counties as reflecting local underlying geology. Not all elements are important. Not all element maps in the USGS Agricultural Soils document are shown herein. Some mapped elements, although locally abundant, also are widespread through Missouri soil, so a high local concentration may not constitute a useful positive anomaly. Beryllium, for example, may occur in shale as well as in igneous rock.

Certain elements are diagnostic of Pegmatite and/or Greisen. A constellation of several diagnostic elements is good evidence of nearby Pegmatite and/or Greisen. The pathfinder elements include beryllium, cerium, fluorine, iodine, lanthanum, lithium, niobium, scandium, selenium, thorium, uranium, ytterbium, and yttrium. And depending on specific geology, maybe iron.

Other Pathfinder element constellations exist for a variety of additional elements. These element groupings should be sought and identified. Even weak anomalies can be important. A weak anomaly may indicate that the sampled site is on the outer edge of mineralization and an ore deposit is somewhere nearby.

ANY local deviation of an element's concentration, whether an excess or deficiency, may indicate an exploration target. A positive anomaly often indicates mineral enrichment. A negative anomaly may indicate hydrothermal or other leaching activity that removed an element and deposited something else, an effect often associated with certain types of gold deposits.

Gold is neither an agricultural asset nor a liability. Gold is biologically inert and has no effect, good or bad, on livestock, crops, or people. But a nice gold deposit offers a welcome economic boost. Pathfinder Elements indicating the presence of gold include silver, copper, lead, zinc, cobalt, nickel, arsenic, antimony, tellurium, selenium, and mercury. And gold itself, of course, although gold concentration often is too low for direct analytical detection.

In the Carter county and vicinity study area, the reported near-absence of soil uranium is curious. Uranium should be there. Lots of uranium. Could be the uranium is locked away in a resistant mineral such as Monazite and is unavailable for dispersion in groundwater.

Uranium's mapped near-absence could be an actual absence or an analysis method failure and is a problem best left for field research to solve. It is possible that uranium of natural origin could be completely absent, and the scant reported uranium was introduced in fertilizer. We'll see as the area geochemical study progresses.

The message takeaway is soil geochemistry does support the presence of a large Pegmatite/Greisen primary igneous uranium source in Shannon county and extending all the way across southern Reynolds and northern Carter Counties. Remember that only AGRICULTURAL soil was sampled, so the full extent of the area enriched with exotic elements is probably much larger than the soil analysis maps indicate.

COMPLEX GEOLOGY? YES!

Minerals Exploration Geologists have a saying, "Complex Geology Makes Good Ore Deposits." Is there complex geology under Shannon and Carter Counties? Oh, YES!!!

The collapsed caldera remnant of a very large Precambrian volcano, the Eminence - Van Buren (EVB) volcano, exists under Shannon and Carter counties and for a long distance outward. Geologists have found erupted volcanic rock 5 miles thick within the caldera. And that's the PRESERVED volcanic rock, not counting the 1 to 2 miles of rock removed by erosion after eruptions stopped. The magma chamber was quite large to have supplied that much erupted rock. There was ample magma volume for rejected elements fractionation to create very large Pegmatite and Greisen exotic minerals deposits.

The EVB volcano is located at almost the center of the Gravity-indicated Asteroid Impact structure, and also within the Missouri Gravity Low granite batholith. The location lies along the High Conductivity Zone found during the recent Magnetotelluric Survey, and along a major fracture system, the Grand River Tectonic Zone (GRTZ), a Continental Transform Fault similar to the San Andreas Fault in California.

Complex Geology? WOW!!!

AIRCRAFT CONDUCTING MAGNETIC + GAMMA RAY SPECTROMETRY GEOPHYSICAL SURVEY OVER SOUTHEASTERN MISSOURI

Time for some definitions. At this research initiation stage, and for simplicity and convenience, all varieties of cancer are considered under the single term "Cancer". All varieties of kidney disease are considered under the single term "Kidney Disease". Obviously, this is a very broad generalization that will quickly undergo refinement into separate disease categories as research gets underway. But for now, the catchall term "Cancer" will suffice and is understood to predominantly refer to Lung Cancer. Same generalization for kidney disease.

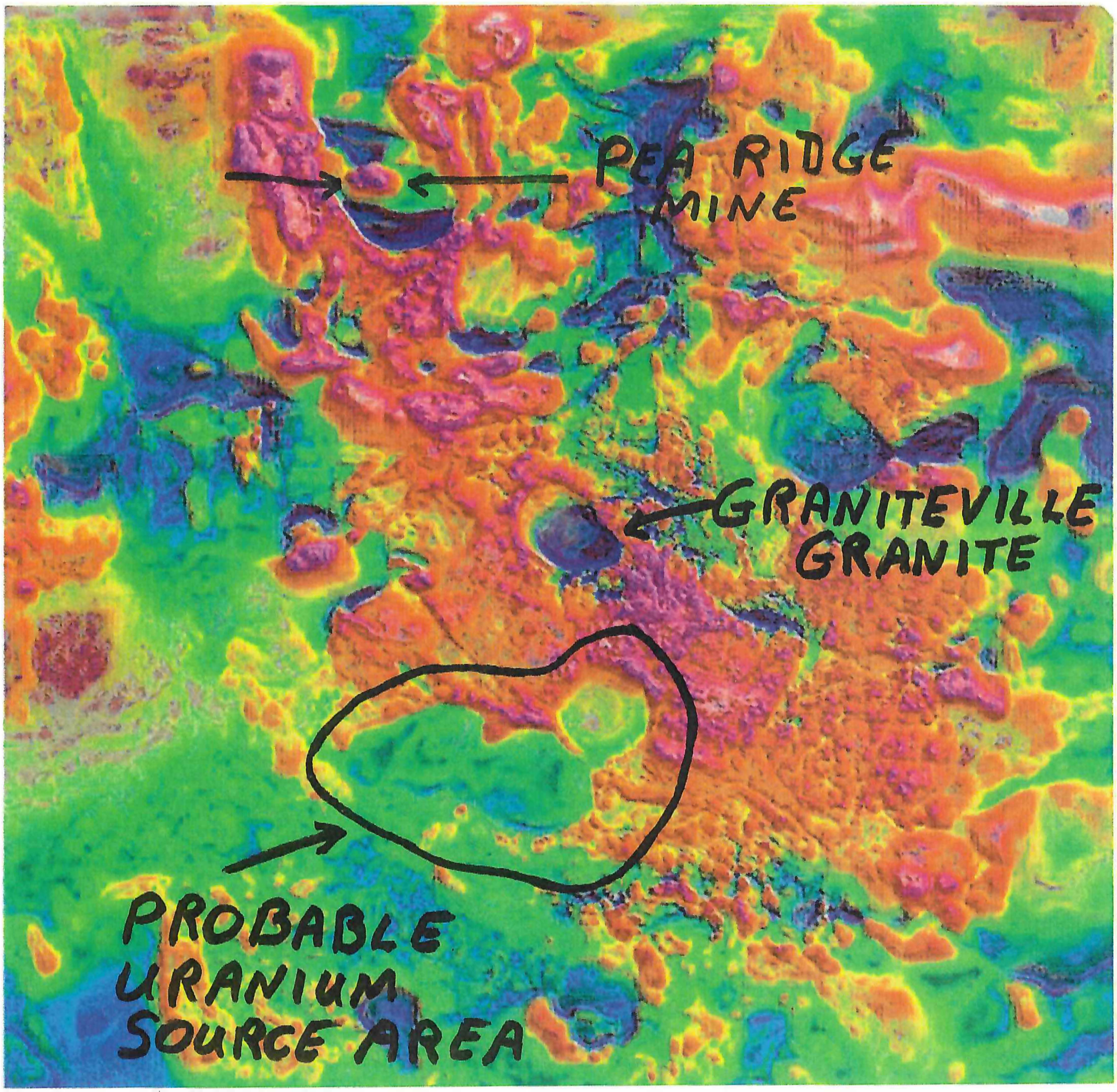
Is there geological connectivity with cancer and kidney disease?

Yes.

The connection is environmental Uranium including uranium's radioactive decay

USGS
science for a changing world

Earth MRI - Shaded relief map of high-resolution magnetic anomaly data



(Credit: McCafferty. Public domain.)

products, particularly radium and radon.

Uranium is itself a direct, chemical cause of kidney disease. Radioactivity is not involved.

Radium and radon are direct, radioactive, not chemical, causes of lung cancer.

At the generally low environmental concentrations present in the Southeastern Missouri Cancer Belt, uranium, radium, and radon exposure must be chronic to be health hazards. A year or two of exposure is normally not harmful. Decades of exposure are generally required for uranium-related diseases to develop.

The Southeast Missouri Cancer Belt is underlain by Precambrian gneiss, schist, granite, and volcanic rock derived from granite magma. Granite and volcanic rock are both enriched in radioactive uranium, thorium, and potassium. Potassium is not a player. Uranium and thorium both emit radon during radioactive decay. Radon from thorium ('thoron') has a half-life of about one minute and quickly goes away. Radon from uranium via radium has a half-life of 3.8 days, providing enough time to be ingested and do biological damage.

Carter county is part of the Cancer Belt and gets the normal regional share of uranium, radium, and radon. But Carter county's rates of cancer and kidney disease are quite a lot higher than all the other Cancer Belt counties. Why is that?

The simplest answer is that some geological features, igneous and Precambrian, and/or younger and probably redox connected, in Carter county and probably also in adjacent Shannon and Reynolds counties, are enriched with uranium and are sending that locally sourced additional uranium along with regional uranium into Carter county's soil and groundwater. That extra-concentrated environmental uranium can be present in household water wells and also gets adsorbed into surface soil and thereby into vegetable gardens and into pastures where animals graze and pass uranium up the food chain to people who eat the animals.

Geochemical mapping in Carter county is expected to show increased environmental uranium, particularly in and around cancer clusters. When enough data accumulate, the plot of cancer and kidney disease vs. environmental uranium probably can be curve-fitted into an empirical exponential equation of the general form

$$\textbf{(uranium)}\ (x^y) \Leftrightarrow \textbf{(cancer + kidney disease)}$$

useful for predicting disease rate if the local environmental uranium concentration is known, or the opposite, predicting uranium concentration if the local disease rate is known. This correspondence will be useful in other areas of the Cancer Belt if the thesis model is verified and could reduce fieldwork and expense when evaluating other counties.

As a bonus, cancer + kidney disease <=> uranium data also are directly useful for minerals exploration for Precambrian Pegmatite and Greisen deposits of exotic elements (and probably some gemstones such as emerald, ruby, amethyst, and tourmaline) and for redox-related uranium deposits. That could lead to a vibrant mining industry producing strategic and critical minerals, including rare-earths, that attracts high-paying, high-tech industries to the somewhat economically depressed area of Carter county and vicinity.

SANDSTONE DYNAMICS

The conceptual model strongly suggests that the southeast Missouri regional cancer and kidney disease epidemic is caused by a combination of tobacco use, mainly smoking, and chronic exposure to some major elements, natural chemical compounds, and/or unrecognized trace elements in rocks, soil, and groundwater. Synergy is possible, even likely.

Uranium and other elements, deposited in Roubidoux and Lamotte (and Gunter?) sandstone formations by the influx of hydrothermal water that introduced lead ore deposits, are now undergoing active remobilization and relocation as erosion removes the sandstone.

Uranium in Carter county is moving down-dip and south with groundwater flow, possibly creating new uranium mineral deposits and enlarging existing deposits. At the same time, renewed oxidizing chemistry in the eroding sandstone is dissolving older uranium deposits and increasing the local content of dissolved uranium in groundwater entering domestic water wells.

Remnant Roubidoux sandstone outcropping in Carter county, and continuing to the north toward but not reaching Reynolds county, (Roubidoux was removed by erosion in Reynolds county) at some earlier time and up-dip pre-removal location should have come into contact with mineral-enriched groundwater, and possibly into direct contact with Precambrian intrusive and/or volcanic rock (and/or derived conglomerate) that passed as magma through the Impact Structure center.

It is likely that groundwater has been and still is depositing in Roubidoux sandstone some carcinogenic element or combination of elements originating from Precambrian volcanic rock or present in the geochemical hydrothermal alteration halo accompanying a hidden nearby lead/zinc deposit.

Relocation of elements, particularly uranium, from Precambrian rocks and redox deposits and into Roubidoux and Lamotte sandstone formations, likely happened to some degree during the hydrothermal introduction of lead deposits.

That could explain the original source of uranium in bat-related small uranium deposits in Roubidoux sandstone and the associated high local concentrations of cancer and kidney disease clusters in Carter county.

When the Carter county area has an airborne gamma-ray spectrometry survey, Roubidoux sandstone is expected to show overall higher radioactivity than areas where dolomite is the surface rock.

THE ATHABASCA MODEL

The Athabasca Basin is a region in the Canadian Shield of northern Saskatchewan and Alberta, Canada, famous among mining geologists as the location of the world's richest uranium deposits, with some deposits reaching grades in excess of 25% uranium (U_3O_8). Worldwide, uranium deposits typically contain about 1% or lower uranium.

The Athabasca uranium deposits are called "Unconformity" deposits because they developed at a geological 'unconformity', or major time break, between rock formations.

The distinctive geology of Athabasca unconformity uranium deposits is a long-lasting, immobile source of chemically reducing solutions that issue upward from reactivated basement faults that cut across the interface between older igneous and metamorphic rocks and younger overlying sandstone. Because faults supplying the reducing fluids remained fixed in place, the fluids causing uranium precipitation keep uranium accumulating in one location for a long time and create large and very rich uranium deposits.

The fluids are thought to enter older basement rock along faults cutting through rocks enriched with graphite and sulfides that create reducing chemistry in the moving deep water. As water exits the fault upward at the unconformity between older igneous/metamorphic rocks and overlying sandstone, the chemically reducing up-flowing water causes groundwater uranium precipitation in the sandstone.

Luis A. Parra-Avila studied the geology of Doe Run company's lead deposit at Higdon in the northeastern corner of Madison county, Missouri (near Fredericktown), and adjacent Perry county, and found weak uranium mineralization in Lamotte sandstone. The uranium geology at Higdon is similar to the Athabasca uranium deposits in Canada, suggesting that the Athabasca model has been active in southeastern Missouri although probably on a much smaller scale than in Canada.

The areal extent of uranium mineralization at Higdon is unknown but likely is connected with radionuclide contamination in nearby Farmington's municipal well water. The Higdon low-grade uranium deposit could be restricted to the immediate Higdon area or extend across a much larger area, although probably in a patchy pattern, as just one of many similar uranium deposits throughout the entire southeast Missouri Cancer Corridor. Lower incidence rates of cancer to the east may be due to fewer uranium deposits or just due to greater depth of uranium host rocks as the rock formations plunge into the Illinois Basin.

Higdon Mine Waste Not Expected To Be An Environmental Hazard

Lead ore in the deposit at Higdon resides in Bonneterre formation dolomite host rock substantially above the uranium-bearing Lamotte formation sandstone. Mine development waste rock is not likely to extend as deeply as the Lamotte sandstone. Mill tailings are unlikely to contain any Lamotte sandstone. There should be no health problems for miners and neighboring landowners from uranium in the Lamotte sandstone underlying the layer of rock mined for lead.

More Uranium Likely In Carter County

However, similar uranium deposits in Carter county, Missouri (Van Buren area), could be substantially larger and richer than the Higdon uranium deposit and may be the primary source of uranium causing Carter county's high rate of cancer and kidney disease.

Carter county is located within both the asteroid impact structure and the Missouri Batholith. The Magnetotelluric Survey deep electrical conductivity zone caused by enriched graphite and/or sulfides underlies Carter county. These features could combine to form a long-lasting source of chemically reducing fluids exiting from a stationary Precambrian fault into uranium-enriched groundwater flowing through Carter county in Precambrian paleostream channels, and in overlying Lamotte sandstone where the Lamotte formation is present, causing deposition of large and rich, narrow, horizontal uranium deposits in the buried paleo river channel sand and gravel.

Athabasca-type uranium deposits that actually are high tonnage/high grade would more likely form in paleostream channels of rivers flowing across the buried Precambrian paleosurface than in the much more extensive (but not present everywhere) Lamotte sandstone. Because the paleostream channels are rather small features regionally, similar in length and width to modern Ozarks river channels, uranium mineralization could be concentrated within a small volume of host rock and result in higher-grade uranium deposits. This could occur if a stationary fault discharging chemically reducing water crosses a paleostream channel transmitting uranium-enriched groundwater, a geologically likely and probably fairly common condition in Carter county.

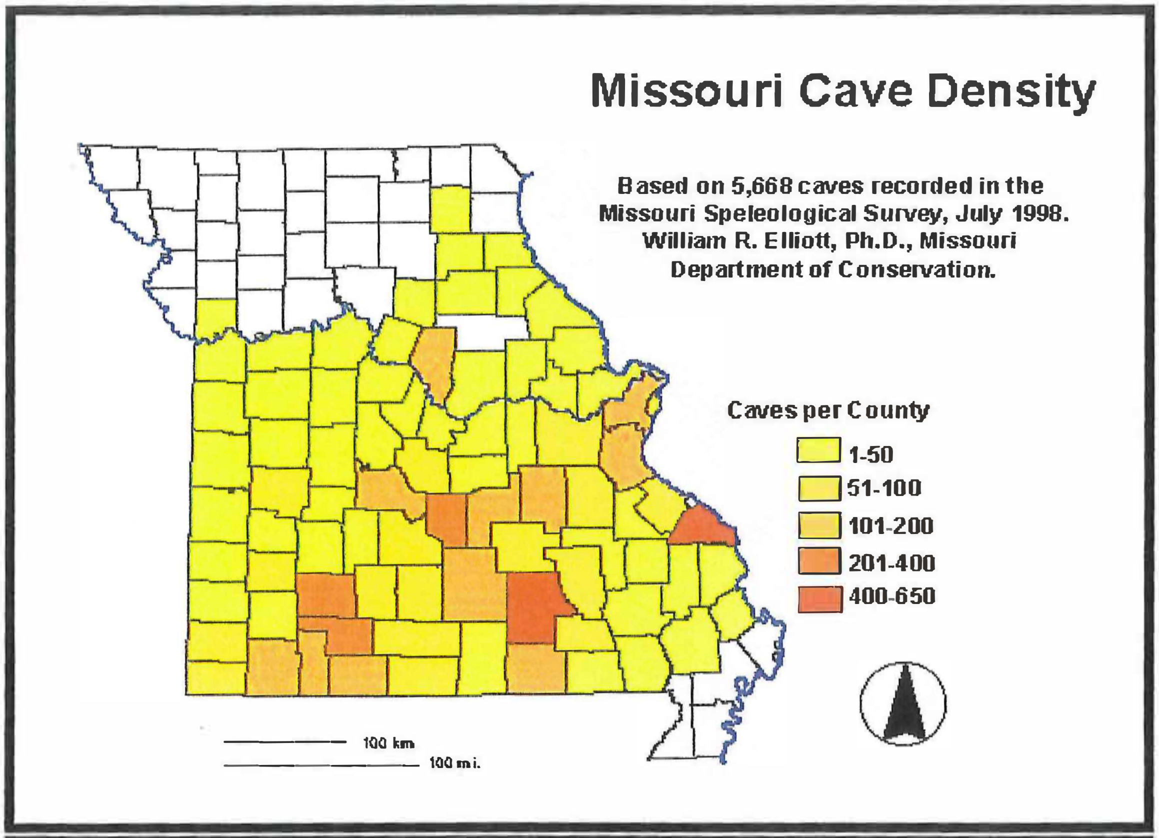
However, Carter county uranium deposits need not be bonanza grade to increase the incidence of cancer and kidney disease. Just abundant uranium at a few tenths (0.X%) percent concentration would be sufficient, or even as low as several hundred parts-per-million concentration. And the uranium source deposits would not even need to be in Carter county provided they are along the paleostream and Lamotte sandstone flow paths of hydrothermal solutions that brought in the large lead deposits. Uranium source deposits could even be in northern Arkansas.

Where Lamotte formation is present, beds of Arkose in contact with the Precambrian paleosurface may themselves have been a a source of uranium held in feldspar grains locally derived from uranium-enriched igneous rocks. Up-dip uranium enrichment could result from hydrothermal relocation of intra-formational uranium without requiring an external uranium source.

Inflowing hydrothermal fluids that emplaced lead deposits could have scavenged uranium from Athabasca-type deposits and carried that uranium upstream along the groundwater flow path, causing uranium enrichment in Carter county and vicinity's Lamotte, Gunter (?), and Roubidoux sandstone formations. That explains how uranium could get into sandstone formations at stratigraphically higher locations.

Up-dip uranium deposition produced by migrating hydrothermal fluids that brought in lead deposits, coupled with uranium leached and currently leaching from underlying Precambrian rocks, could explain sandstone formation uranium enrichment and the resulting elevated levels of cancer and kidney disease in southeastern Missouri's Cancer Corridor.

A BATTY SITUATION



Uranium in geological environments exists mainly in two oxidation states: Hexavalent U^{+6} and Quadrivalent U^{+4}.

Hexavalent U^{+6} uranium dissolves in groundwater and moves with groundwater flow. Quadrivalent U^{+4} uranium is not soluble in groundwater and precipitates to create uranium deposits. Depending on geochemical conditions, uranium can switch back and forth between quadrivalent and hexavalent valence states.

Uranium in Western states forms 'Roll Front' deposits, among other types. Hexavalent uranium in groundwater flowing through sandstone continues moving as long as sandstone groundwater geochemistry remains oxidizing. At some point, organic plant material (called Trash Pockets by miners) may be encountered within the sandstone, creating a chemically reducing local condition that causes dissolved U^{+6} uranium to change to the quadrivalent U^{+4} condition and precipitate as rock, becoming a mineral deposit or even an ore deposit. Uranium converted from U^{+6} to U^{+4} stops passing through in groundwater and accumulates as a Roll Front deposit in the sandstone.

A Roll Front deposit typically migrates downstream in the direction of groundwater flow as oxygenated groundwater continues to arrive, oxidizes and consumes the organic matter, and briefly reoxidizes already deposited upstream U^{+4} uranium back to the water-soluble U^{+6} condition. Radium and radon of local origin begin to accumulate by radioactive decay of the uranium.

The proposed epidemiological cancer survey of Carter county will likely establish that high cancer incidence is not county-wide but is limited to cancer clusters, separated islands of higher cancer rate cases in a regional field of normal cancer rate. How could this be?

Uranium dissolved in groundwater is everywhere to some degree. To make uranium precipitate from groundwater and create uranium mineral deposits, chemically reducing materials, typically of organic origin, can be originally present in rocks or injected into passing groundwater. This condition can be determined by testing REDOX POTENTIAL, Eh.

Groundwater Redox Potential should be tested at the wellhead within a few minutes of sample collection. Eh changes during storage and will give incorrect values if the water is taken back to a laboratory for testing. Mapping groundwater Eh may provide a regional understanding of organic materials ("Bat Poop Soup") in groundwater and identify likely areas of aquifer uranium mineralization.

Almost all caves develop in Limestone and/or Dolomite CARBONATE rock. JOINTS are vertical cracks through the rock that allow passage of groundwater from the surface downward. A cave forms where host rock is dissolved by groundwater causing a joint to extended outward laterally, creating a somewhat tubular passage through the rock. The descending joint along which the cave formed, usually covered by rubble and sediment on the cave floor, continues down below the cave floor for a considerable distance, often tens to hundreds of feet and sometimes, even more, offering downward passage to cave groundwater and contained organic materials in solution. In this way, guano leachate originating in a cave at higher elevation may be able to enter a sandstone aquifer located considerably below the cave floor.

Carter county is an active karst area where caves have been forming and growing bigger for millions of years.

Bats first appeared in the fossil record 55,000,000 years ago.

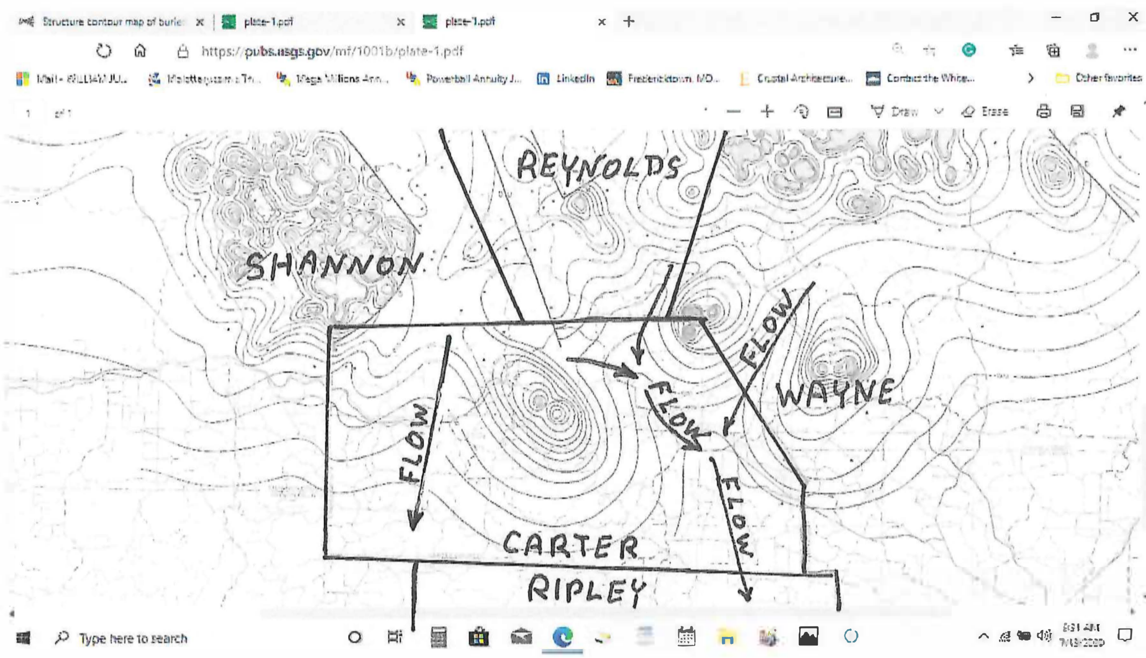
Bats think caves are wonderful! Free Housing! Bats move in and create colonies that can number thousands to tens of thousands of individuals and they have done so for many thousands of years. Actually, more like many TENS of thousands of years. The Missouri Cave Density map white area of zero caves at the top of the map represents the extent of bedrock covered by glacial till during the recent Ice Age. Glaciers did not come as far south as southeastern Missouri. Bat caves remained open during the recent Ice Age and bats have been active in southeastern Missouri for a very long time, producing a steady point-source stream of Bat Poop Soup organic matter reductant that changed local groundwater chemistry and created small uranium deposits in sandstone under the bat caves. Think of this as an upside-down Athabasca uranium deposit model with a downward-flowing chemical reductant. At some places, uranium deposits may remain even though erosion has removed the bat caves and the cave host rock. A currently existing, active bat cave is not required for the presence of a preserved uranium deposit.

As deposited, fresh bat guano pH is 5.1 to 7.3, but with age becomes much more acidic, pH 2.7 - 4.1, which is acidic enough to dissolve the limestone and dolomite rock in which most caves are developed. Guano has a high content of nitrogen and potassium which may combine to form Potassium Nitrate, an ingredient of black gunpowder, that historically has been mined for that purpose from guano deposits in bat caves.

Nitrate also is involved in mobilizing Uranium in groundwater. Elevated concentrations of Nitrate and Uranium often are found together in groundwater. That raises a subject for further research. If organic leachate in Bat Poop Soup causes precipitation of Uranium from groundwater in sandstone, and Nitrate in the same organic mix dissolves and mobilizes Uranium, to what degree does Bat Poop Soup influence the creation of Uranium deposits?

Bat caves are a long term, point source of chemically reducing dissolved organic matter. That's exactly what is needed to cause uranium^{+4} precipitation in sandstone. A major primary source of the dissolved groundwater uranium is a likely to be regional uranium-enriched volcanic rock from volcanoes erupting magma from the mid-north Crater area where Graniteville, Butler Hill, and Breadtray granites enriched with uranium and thorium are located. Other probable uranium sources are Precambrian Carbonatite, Syenite, and/or Pegmatite/Greisen intrusive rocks in Reynolds county and northern Carter county.

Where intrusive igneous rocks host uranium deposits other strategic and critical materials such as rare-earths commonly are present. There could be large Precambrian ore deposits in intrusive igneous rocks and/or derived conglomerates in northern Carter and Reynolds Counties. See earlier Carbonatite comment on *Ozarkcollenia* stromatolite algae fossils in Iron county.



PRECAMBRIAN PALEOSURFACE STRUCTURE CONTOURS.

URANIUM-ENRICHED GROUNDWATER GATHERED FROM A LARGE AREA OF IGNEOUS ROCKS TO THE NORTH IS FUNNELED THROUGH CARTER COUNTY ALONG THE PRECAMBRIAN PALEOSURFACE AND THROUGH OVERLYING AQUIFERS.

Bat droppings and dead bats pile up on the cave floor. Bugs appear and feast on the organic matter. Bugs also die and pile up. Groundwater passing through the cave leaches soluble organic matter and carries this downward, eventually entering an underlying sandstone aquifer, where dissolved organic matter locally changes groundwater chemistry from oxidizing to reducing, and passing uranium is captured as a mineral deposit.

Uranium deposits created in this way would mostly be low grade and small, generally less than 0.1% uranium and a square mile to a few acres in size. Still, they can locally produce a lot of groundwater uranium, radium, and radon compared with surrounding unmineralized rock. If your water well penetrates a uranium deposit and your house basement is in the ground atop a deposit, you have a radionuclide problem.

Radium can travel in groundwater with or separately from uranium. Radium and radon at your house could originate from a small uranium deposit a mile away and upstream on the groundwater flow path. You could have a uranium/radium/radon water problem and your neighbor getting water from the same aquifer a quarter mile away may not.

Kidney Disease can result from chronic exposure to trace element uranium. This is a chemical effect, not a radioactivity effect. Chronic uranium ingestion can occur from drinking well water containing a low concentration of uranium, eating garden plants grown on soil containing uranium, and eating wild and domestic animals that graze on pasture plants grown on soil containing uranium. Reducing exposure to natural environmental uranium should reduce new cases of both kidney disease and cancer.

Bright Side? If uranium is concentrated enough in groundwater, most likely to occur in Lamotte formation sandstone at the Precambrian paleosurface in paleostream channels and/or in derived conglomerates, it may be possible to commercially recover uranium from groundwater.

Production wells bring uranium-enriched water to the surface where uranium is removed. Disposal wells return demineralized water to the Precambrian aquifer. Water is borrowed, not consumed. Water production from overlying aquifers is not affected.

If economics are favorable, Carter county and maybe southern Reynolds county could become a significant area of domestic uranium production. With nary a mine in sight.

Supernova Bright Side? For millions of years, groundwater enriched with uranium has been flowing into Carter county where two paleosurface streams merge, then flowing south from Ellsinore to Ripley county and northern Arkansas. That's an ENORMOUS cumulative amount of uranium! Where did it all go?

That's beyond the scope of this study. But how much of that uranium converted to quadrivalent and created ore deposits? Gazillions of tons, possibly. It depends on the availability of a chemically reducing environment somewhere along the groundwater flow path from mid-Carter county south. There are petroleum exploration leases in Carter county, and petroleum components can be chemically reducing. If uranium deposition happened, Bonanza-size ore deposits in rock could have been created. Definitely worth looking into. If the petroleum leases were drilled, check the gamma-ray well logs.

WHAT NEXT?

The conceptual model does not ***PROVE*** a geology/cancer connection. To do that, a formal investigation must be done. And it's a very good idea to define success and an exit strategy before starting work. Looking ahead, and assuming success with identifying the cause of elevated cancer rate, what if anything can and should be done to fix the problem?

Resources are always limited. Remediation of every square foot of land in an affected county is not possible. Doing so would upend the existing environment and likely cause more damage to the health of humans and wildlife than any benefits the cleanup could produce. So be realistic, not radical, when planning and conducting a geological program to identify the cause and planning an approach to reduce the area's high rate of cancer.

First, it is necessary to know the density and distribution of cancer and kidney disease. Quite likely, high cancer incidence is concentrated in a few small areas and not spread generally throughout the county. The cancer source may be genetic, not environmental. It may be related to other factors such as exposure to herbicides and insect sprays. This sort of opening exploratory activity is standard during the epidemiological assessment. Public health records, if available, are a place to start. Much necessary information probably already exists.

Use local media and meetings to ask for public support. Encourage citizens to allow their medical information to be collected, without releasing personal identification, for use in the cancer survey. Initially, only individuals who have or had cancer need to be entered into the database. But after this first data collection is finished, include presently healthy local volunteers to follow as they grow older and possibly develop cancer in the future.

Ask for and analyze tissue samples such as hair, teeth, bones, and cremation ashes, to build a mineral profile of healthy and cancerous people. Use sensitive, nondestructive, or small sample requirement analysis methods and securely store remaining material to preserve for future study possibly tens of years later. Plasma/Mass Spectrometry and Neutron Activation currently are suitable analysis methods. X-ray fluorescense may be useful if the lower detection limits are high enough.

This is standard procedure so far and in common use for investigations of this nature.

At the same time, begin the geological work. If possible, hire a geologist familiar with geochemical exploration for minerals. Test for the obvious, such as lead and arsenic in rocks, soil, and water. Use an accurate analysis method that can handle both major elements and trace elements down to no less than parts-per-million and preferably parts-per-billion. Even tiny amounts are important during decades of chronic exposure.

Routinely measure the concentration of as many elements as possible, from uranium to lithium. Potential carcinogenic materials in local rocks and water are presently unknown, so analyze for everything possible until correlation with cancer emerges. The active carcinogenic agent could even be organic.

Then put the data together. Identify the problem materials, the problem land areas, the problem geology, and any other factors that emerge.

Straightforward, simple, fairly inexpensive, and fast, so far.

IS THERE RADON IN YOUR HOME?

Yes. There is radon in your home. Radon is a natural part of air above land. The critical factor is not the **presence** of radon, it is the **concentration** of radon.

The Missouri Department of Health and Senior Services acquired a grant from the U.S. Environmental Protection Agency to provide one free radon test kit yearly to Missouri residents. The other States may have similar programs.

The free test kit is the Activated Charcoal type in a plastic tray about the size of your hand. The test is started by peeling off a protective plastic film, exposing the paper cover over the charcoal. Hang the test kit on a wall according to directions. After a few days of exposure take down the kit and return it to the laboratory for analysis.

Radon test kits are generally inexpensive, come in a variety of types for different applications, and are available everywhere by mail including locations where they are not provided free. Some retail stores sell radon measurement kits.

As of December, 2020, when this document you are reading was published, free home radon test kits for Missouri residents were available from:

Missouri Department of Health and Senior Services
912 Wildwood
P.O. Box 570
Jefferson City, Missouri 65102
Phone: 573-751-6400
Fax: 573-751-6010
Email: info@health.mo.gov
Radon Test Kits: https://health.mo.gov/living/environment/radon/index.php

REMEDIATION?

It depends. Is the active area spread over hundreds of square miles or just a few peoples' yards? Is the problem something that can reasonably be fixed by a method such as removing the upper two feet of soil around a building or from a home food garden and replacing it with clean dirt?

To their credit, folks at the US Environmental Protection Agency have actually reduced blood lead levels of residents at Fredericktown in Madison county, Missouri, by replacing soil contaminated years ago by homeowners who used dolomite mill tailings from lead mining to lime the soil around the yard so grass would grow better.

The Madison county effort has actually been cooperative between EPA and property owners, unlike the broadaxe policy implementation methods traditionally forced on landowners by direct descendants of Ghengis Khan and his Mongol hordes of previous years, who earned for their government environmental and wildlife agency employers a thoroughly justified horrible reputation.

It also depends on whether the problem is one of deficiency or excess.

If human and livestock health is suffering due to a lack of something, perhaps a feed supplement or a pill would fix the problem at very little expense. That's how vitamin pills work.

A problem of excess, such as elevated soil cobalt, is much harder and usually impossible or hugely expensive to fix. How do you get rid of too much soil arsenic in 2,000 acres of cattle pasture? Essentially impossible. Could a feed supplement neutralize the substance?

If a well water problem, there are ion exchange and other types of filter that inexpensively remove the offending material. Okay for home use, but what if you must provide water for livestock or a large home food garden?

SITE-SPECIFIC TESTING AND REMEDIATION

The proposed Carter county-wide research project is aimed at understanding the cancer situation generally. But what about very local, your own backyard scale, testing, and remediation?

Many rural folks live on just a few acres of land. If their well is contaminated with radon and/or harmful trace elements the only direction they can go to reach better quality water is downward -- drill a deeper well. Folks who live on larger tracts of a few hundred or more acres have more room to relocate a water well into more favorable geology but probably don't want their well far from their house and can't afford the cost of installing an electric power line to a distant well and the cost of a pipeline from the well to the house. Maintenance and security of a distant well and long pipeline are other issues.

And some people are unlucky enough to own all their land over a Lamotte sand pinchout with sub-ore-grade mineralization, a Precambrian paleostream channel with just enough mineralization to be a health problem or another geological water problem. Some well locations just cannot be fixed.

Regardless of other contaminants also present in groundwater, the most common cancer--related problem in southeast Missouri is probably well water radon gas with or without accompanying groundwater radium and/or uranium. It is possible that radium in groundwater is reacting with and depositing on the metal well pipe or being scavenged by iron oxide water system rust. If so, pipe in a well that has been in service for many years may itself be a continuously increasing source of radon.

Even cementing casing pipe through and extending several tens of feet below sandstone may still allow groundwater from overlying sandstone to enter the well if water is extracted fast enough that drawdown sucks in water from the sandstone.

Easy enough to do a quick check while the pipe is in the well. Run and record a gamma-ray probe scan inside the pipe to measure and record radiation from inside the pipe and rocks on the outside. Also, do a radon test on the water. If you decide to remove the pipe for cleaning or replacement, run another gamma-ray scan on the empty drill hole. Comparison of the two gamma-ray logs will give an idea of how much radiation came from inside and from outside the well pipe. Visual examination of the pipe for rust, manganese oxide deposits, and limescale will find host materials that may contain radium. Radiation from sandstone could be strong, medium, or weak. Most intense radiation would come from a uranium deposit. The next most intense would be shale or igneous rock. Limestone/dolomite signal would be weakest.

High radon concentration comes from the radioactive decay of radium located close to the water intake point. Radium is much worse than radon for health. Radium itself is radioactive and internal radium is a source of internal radon, all inside a person's body where radiation damage occurs. Radium chemically associates with calcium, whether in pipe scale or bones and stays inside a living organism effectively forever. Internal buildup from chronic ingestion of a low concentration of radium over several decades of time promotes cancer.

Radon has a radioactive half-life of 3.8 days and will go away by itself during isolated storage. After 10 half-life intervals have passed, the stored water is essentially free of radon gas (but not radon's radioactive decay products). But storing water for 38 days before use is impractical and gives bacteria the opportunity to grow in the water. Nonradioactive contaminants such as beryllium, iron, and sulfur never go away by themselves.

There are ways to reduce radon in water. Spraying water into an open, ventilated container releases radon from water into the surrounding air. Of course, this spraying process also releases radon into your house when you take a shower bath. Water may need to be sprayed several times to sufficiently reduce radon content.

So, what to do?

Roubidoux sandstone in southeast Missouri is generally 400 feet or less thick and overlies Gasconade and Eminence dolomite rock formations, both potential aquifers. The added expense of drilling all the way down through Roubidoux sandstone and casing, cementing, and completing a water well in a deeper aquifer is fairly minimal.

Depending on location, and at the geographic scale of drilling a household water well, it is time to ask for help and advice from a local water well-drilling contractor familiar with water wells in your area and help from a groundwater geologist at the Department of Natural Resources. Known geological conditions county-wide may or may not exactly apply to a well to be drilled in your back yard.

If the well starts in Roubidoux sandstone the next formation down will likely be Gasconade dolomite with Gunter sandstone at the bottom. Are Gasconade dolomite and Gunter sandstone satisfactory water producers where you live? Will you have the same problem with trace elements in Gunter sandstone that you now have in Roubidoux sandstone? If the well goes a lot deeper, it may reach Lamotte sandstone or even a basal conglomerate or paleostream gravel on the Precambrian paleosurface. Would these formations be satisfactory water producers? Would the water have trace elements contamination? These are the kinds of questions best answered by your local well-drilling contractor and a professional groundwater geologist. Any of the sandstone aquifers including Lamotte may or may not be naturally contaminated. No sense drilling a new well into an old problem.

Most radon problems are likely to occur along faults where the 'Roof Effect' occurs.

Think about rain falling on your roof. Rain is spread out across the entire roof. Then rain runs off and collects in the gutters, where water is more concentrated. Finally, rain enters the downspout and exits as a rush of water much more concentrated than when it first landed on your roof. Radon in a fault structure operates the same way.

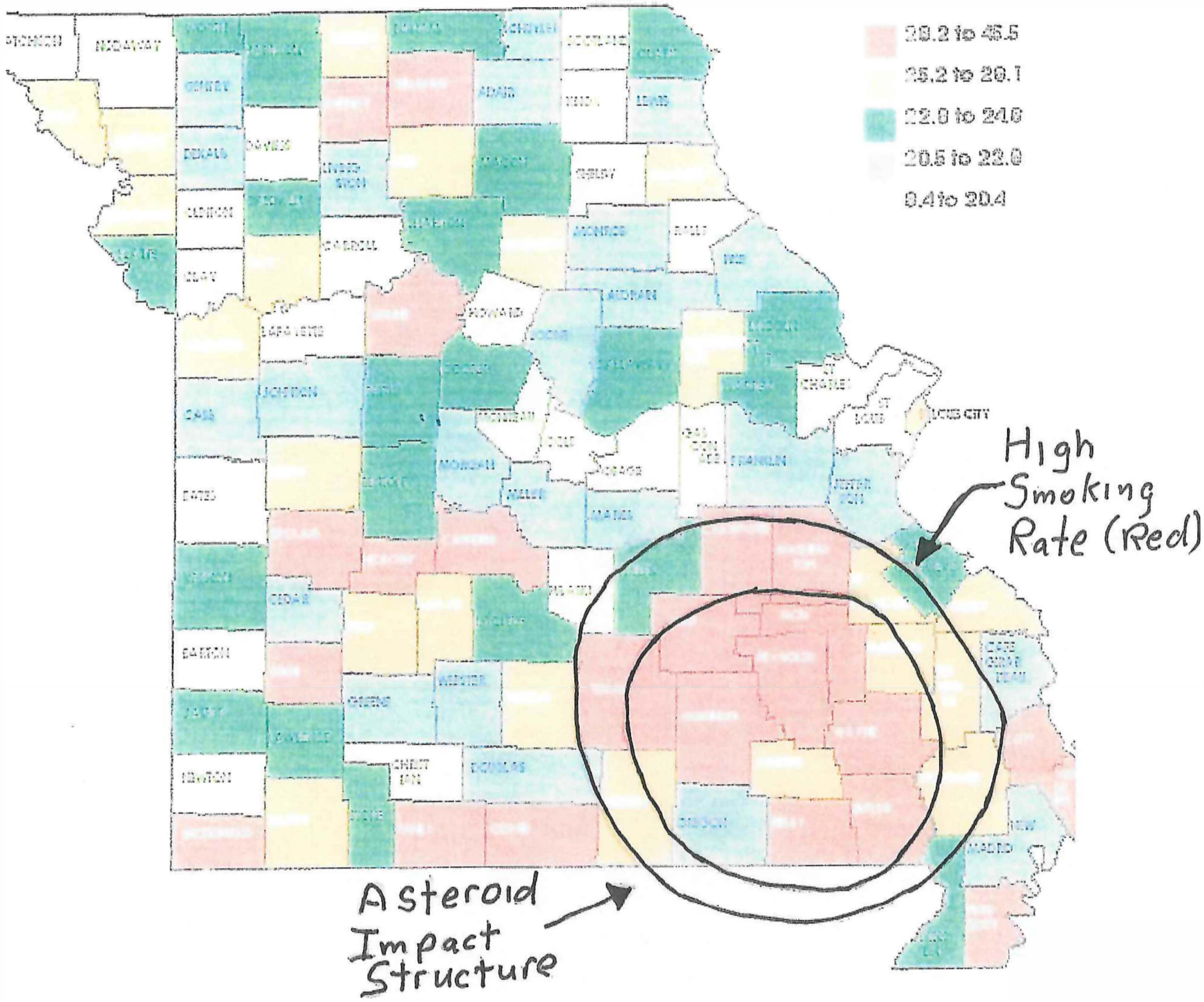
Radon concentration in the rock usually is low. But a fault is a zone of permeability where radon escapes from the rock through a fracture surface that can measure a mile or more in length and hundreds of feet vertically. Your water well provides a collection and exit point where a gush of accumulated radon exits in well water at greatly increased concentration, similar to roof rainwater at the downspout.

So one way to avoid radon is to move off of the fault horizontally if possible and also go deeper to get below the radon source in surface sandstone. That requires drilling a new well in a more favorable location, then pouring cement down the abandoned well to shut off contamination from the surface. Casing pipe should be set and cemented in the new well from the surface through and somewhat below surface sandstone to block contaminated groundwater. As Roubidoux sandstone usually is 400 feet thick or less in southeast Missouri, drilling a new well is probably less expensive than deepening and retrofitting an existing well to draw water from below the surface sandstone.

How do you know if your existing well was drilled into a fault? There are many ways, too many to discuss here, that a geologist can make the determination, and no one way works everywhere. So I'll leave that conversation for another day. Just know that it usually can be done.

Now if people with new wells producing radon-free and harmful trace element-free water would stop smoking the cancer problem would mostly go away.

DOES THE ASTEROID IMPACT STRUCTURE CAUSE SMOKING?



Here is something really weird! I was not looking for this. It just popped up in the data.

The area enclosing the proposed Asteroid Impact Structure and the area of southeastern Missouri with the highest smoking rate OCCUPY THE SAME REAL ESTATE.

Not sort-of, not close, not overlapping. The Asteroid Impact Structure and Highest Smoking Rate are EXACTLY COINCIDENT. Not only coincident, but there is also a radial intensity gradient from the center outward, helping to confirm that an Asteroid/Smoking link may be a real phenomenon. If real, there SHOULD be an intensity gradient. If there are mountains and flatlands there should be foothills.

There are many large Asteroid Impact Structures around the world. Do any others correlate with heavy smoking? Correlate with anything biological or cultural? Correlate with anything?

I have no idea. Random association or a real cause-and-effect? The data are real. The relationship, if any, is mysterious. If you come up with a good answer, please let me know.

BRINGING THE CITIZENS ON BOARD. (YOU HOPE!)

President Nixon's biggest blunder was not the Watergate break-in.

By far, Nixon's worst mistake was signing The Endangered Species Act.

The government went rogue. ESA opened the floodgates to a waiting army of environmentalist zealots hell-bent on 'Saving' the world for the greater glory of Gaia the Earth Goddess, and perfectly willing to shut down the entire national economy and spend the entire Gross National Product to remove that last part-per-trillion of some supposedly offending substance from "The Environment".

Eco-Warriors trampled property rights, agitated (successfully) to put enormous tracts of land off-limits to protect obscure bugs, and generally made total asses of themselves and drew contempt from their normal people victims.

The Missouri Ozarks, including Carter county and environs, suffered the full force of attack by Gaia's minions. Mainly attacks by 'Useful Idiot' minions from large urban areas where residents think they are in Wilderness where houses are more than 100 feet apart. There were movements to restore large predators such as bears and wolves into southern Missouri rural areas although not in suburbs where the agitators themselves lived.

The Natural Streams Act was proposed and put up for voter approval. It failed to pass in every Missouri county. NSA proposed that a Committee of environmentalist Czars would take control of all watersheds, which is the total land area of Missouri, with authority to force landowners to obtain Committee permission to plant or cut down a tree, decide what color to paint the house, what kind of shingles go on the roof, and which vegetables would be allowed in a home garden or even if a person would be permitted to have a garden. Essentially, complete control over every aspect of everyone's' lives.

After a few year's break, Gaia's Green Hoard surged through the Ozarks again, this time proposing to 'Save' the Ozarks by putting a huge contiguous area of land in southern Missouri and northern Arkansas under United Nations control as a Biosphere Reserve administered through Agenda 21.

Rural people would be 'Allowed' to live on their land for a while, but slowly forced to move away into giant ant-nest settlements covering square miles of urban land where access to food, water, electricity, and all other necessities is under government control and could be closed off at any time. 'Core Wilderness Areas' covering hundreds to thousands of square miles would be returned to exclusive occupation by wildlife with no humans and no human activity allowed such as mining, farming, energy production, and everything else. Then disease (natural or intentionally introduced) would sweep through the ant-nest settlements and reduce the human population by 95%. Feudalism and economic slavery overseen by the environmentalist elites would return and rule the world.

If you are interested in this actual contemporary history, do an Internet search on The Natural Streams Act in Missouri, United Nations Biosphere Reserves, Agenda 21, and the article by Tom Uhlenbrock "Ozarks Uproar", St Louis Post-Dispatch (MO), April 6, 1997.

You probably are wondering why all these radicalism references are in the Cancer section of an article on an Asteroid Impact in Missouri.

Good question. Good answer. This is real-life recent history in southeast Missouri where a cancer cause study and possible remediation effort would take place.

Massive abuse by environmental extremists, One World Government types, and federal and even some Missouri government opportunists is quite fresh in the collective memory of local citizens. Whether or not you believe the premise, you will hit a stone wall of public distrust and cancer project rejection if you do not take this recent local history into account as you plan and conduct the cancer project.

It is necessary not only to believe in the worth of a study that could identify and maybe fix the local cancer and kidney disease epidemic but also to see through the eyes of potential beneficiaries and victims. Are you more likely to be greeted with smiles or shotguns? As a savior or as another damned government Greenie Weenie Socialist Gaia Radical come to steal our land by 'Saving' us?

The Missouri Ozarks are still a relatively pristine area coveted by 'Save The World' types. A huge section of prime riverside real estate was taken from private ownership to create the federal Ozark National Scenic Riverways. Did anyone ask property owners for permission to take their land? Doubtful. The land was simply taken away from people who lived there. Landowners were paid for their land but most felt they were victims of extortion and theft. Ill will remains.

There is a definite possibility that a geology/cancer study might cause great financial harm.

Suppose Farmer Brown has a 2,000 acres cattle ranch in the study area. The study finds that Farmer Brown's ranch land is highly enriched with a natural carcinogen. Oops! The dollar value of Farmer Brown's ranch just dropped by 90%. Who would want to live or work on land that causes cancer in its residents? Who would buy Farmer Brown's hay, soybeans, or corn? Who would buy his cattle? Farmer Brown would quickly go broke, his land would be sold at auction for 10% of its previous value, and the ranch likely would be bought by a Nature organization, government agency, or Chinese speculator, transferring still more county land to remote ownership.

County property tax revenue drops a bit more, impacting schools, hospitals, fire departments, road maintenance, and multiple other county government activities.

Government agencies that buy privately-owned rural land, such as the US Forest Service, may promise to make up the property tax financial shortfall through PILT - Payment In Lieu of Taxes -, but rarely pay the full amount promised.

Days later Farmer Brown is all over television and print media. Reporters track you down. Radical Greenies cheer. Your project funding is canceled. Your sponsors are sued. Agenda 21 takes another baby step forward.

Farmer Brown was much better off before the cancer survey. He's probably one of the genetically resistant people who will live to be 110 years old and never get cancer. Total personal disaster!

Completely avoidable if the project is done properly, respectfully, and benefits (not punishes) local people and does not try to steal their land.

The list of considerations goes on and is long. When organizing a regional cancer research project remember the essence of the Hippocratic Oath: First, Do No Harm. Doing nothing may be the best response to a problem.

CONCLUSION

This has been an interesting scientific ramble. Starting with the observation of a faint but definite big circle of lower gravity intensity on the Missouri Gravity Map, that led to postulating an ancient Asteroid impact, creation of a Mantle Plume, widespread volcanic eruption, recognition of massive IOCG Exploration Targets, tons of buried diamonds, a low population of fossils, Missouri's world-class lead/zinc ore deposits, recognition of a possible geological cause of excess cancer in southeast Missouri, ideas to determine the cancer cause and possible remediation, involvement by bats, a lesson on contemporary history, and tips for fruitful public relations.

Quite a span. But that's typical of science. One thing commonly leads to many others.

When can you expect to see results? It will be a few years after this research gets started.

Good science is done carefully and slowly. It's not a race. The goal is to get the work done correctly.

Initial geological and epidemiological work will take 2 - 4 years. Initial remediation another 3 - 5 years. Results should start to appear about 4 - 6 years later. Research will continue for several more decades to follow progress and make necessary adjustments.

Results are never guaranteed. But if the epidemiological and geological models are validated, and remediation is successful, and concurrent minerals exploration results in new mines that attract high-tech industries, you may notice that people living in rural southeast Missouri are becoming richer and healthier.

All because a big rock fell out of the sky ~1,500,000,000 years ago.

Actions have consequences.

Even for rocks.

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williamjud@hotmail.com
website: www.legendminerals.com

ASTEROID IMPACT STUDY AREA

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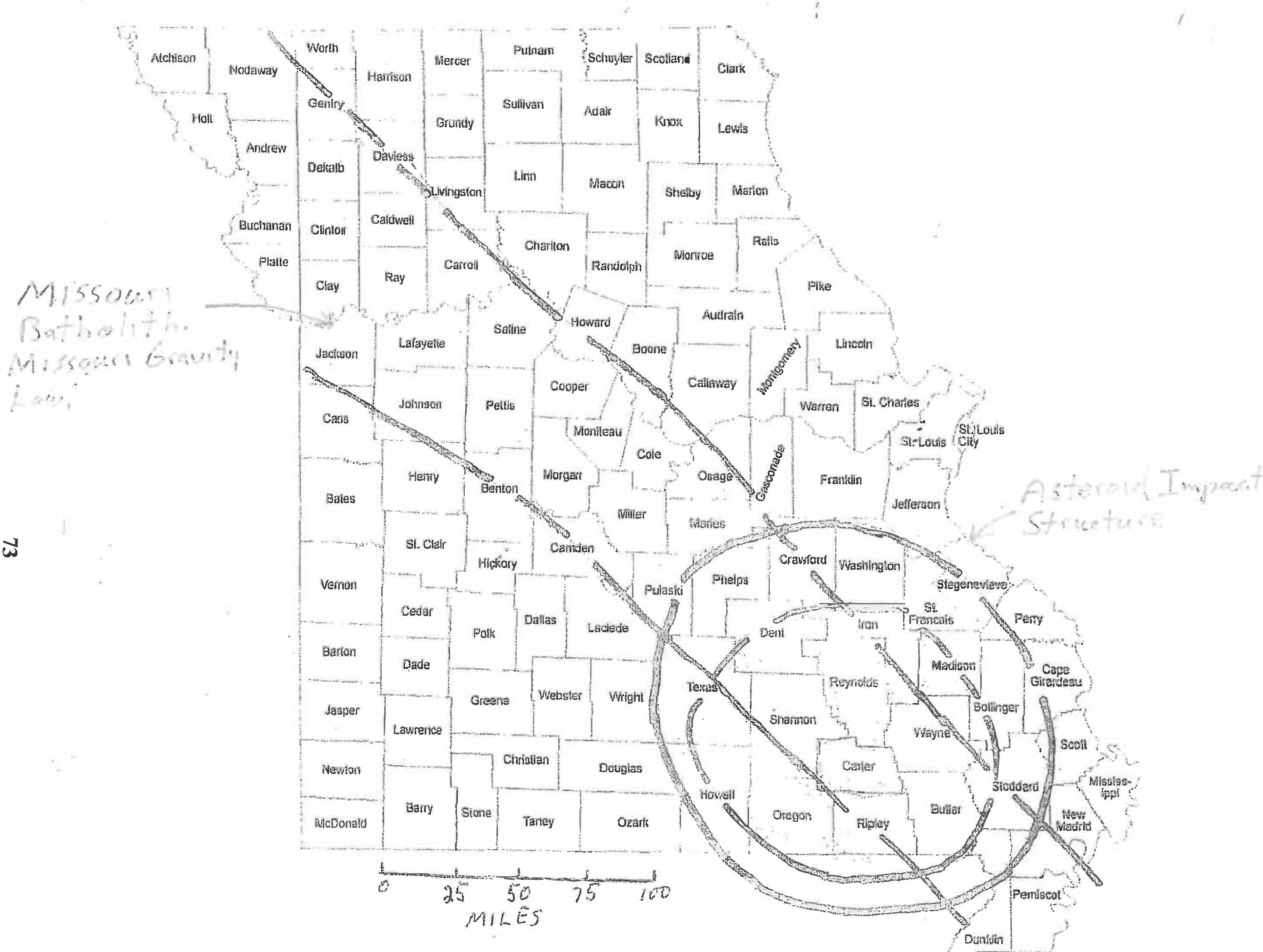

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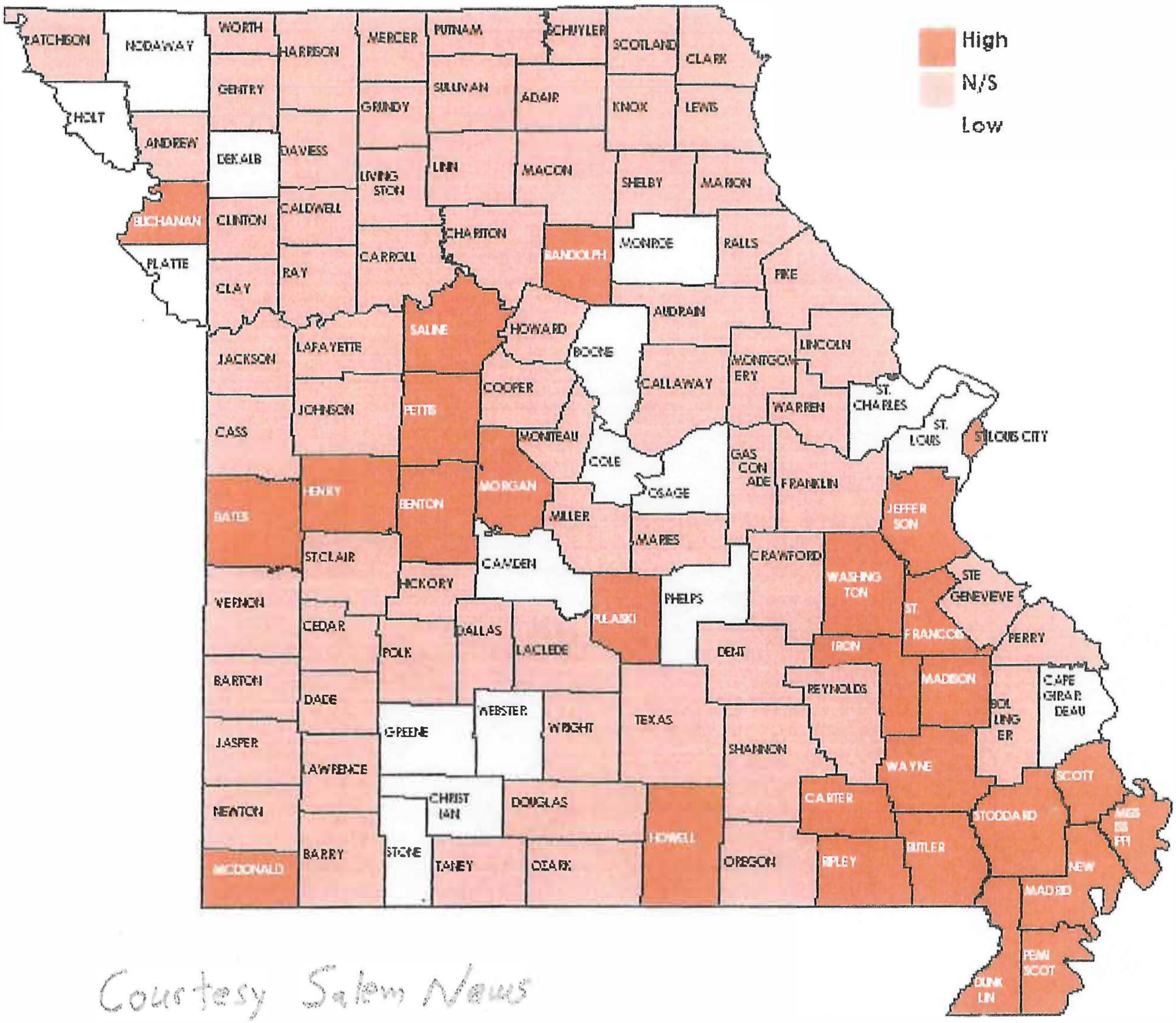
CANCER



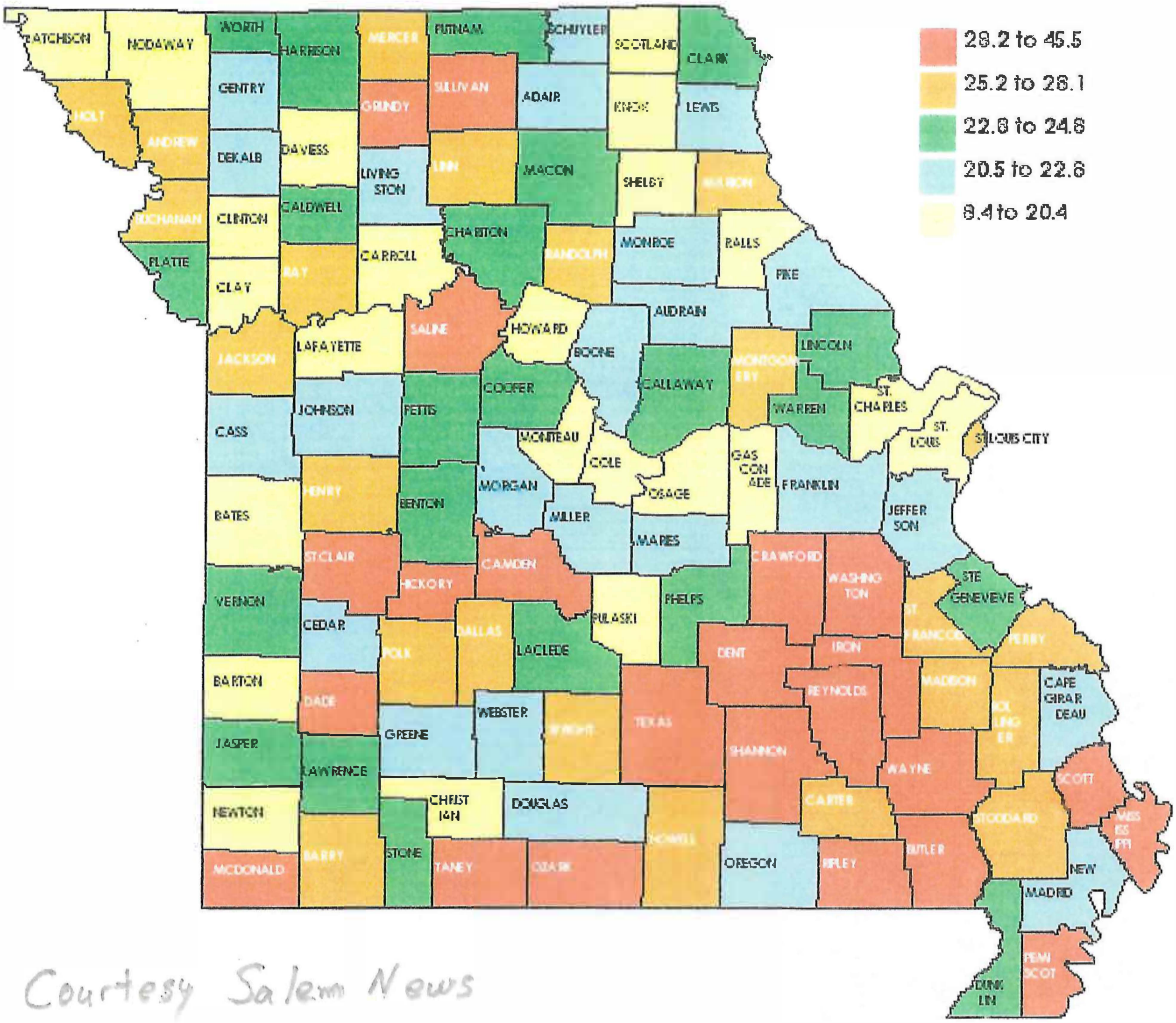
To Dent County's south and east, 15 counties form an unbroken block of significantly high cancer death stretching from New Madrid County in the bootheel, all the way north to Jefferson County in metro St. Louis, and west to nearby Carter County.

Courtesy of Missouri Information for Community Assessment

Dent County directly borders this cancer block by way of its neighbor Iron County, but it is not a member. The county's cancer death rate of 202.2 cases per 100,000 people is above the Missouri average of 191.1, according to the MICA data. Statistically, however, this figure is not significantly higher than the state average.

To the east and south, however, the cancer burden is massive. Neighboring Iron County's cancer death rate is 232.2, Shannon County 214.1, Crawford 205.4 and Reynolds 204.1, per MICA.

SMOKING



Courtesy Salem News

Carter County's smoking rate is less than all of its neighbors but one. Yet is lung cancer rate is on average 48 point higher.

Courtesy of the Missouri Department of Health and Senior Services.

When asked to comment on the lung cancer rates, the Missouri Department of Health and Senior Services responded by email:

"Smoking greatly increases someone's chances of developing lung cancer and the state has many resources available to assist people who are trying to quit using tobacco products. One of the biggest resources is the Missouri Tobacco Quitline. This hotline and web service provides a trained quit coach and other resources to people

Carter 1 of 2

(https://www.usgs.gov/)

Geologic units in Carter county, Missouri

(sgmc-unit.php?unit=MOOr%3B0)

Roubidoux Formation (sgmc-unit.php?unit=MOOr%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 52 % of this area*

Sandstone, chert and interbedded dolomite

(sgmc-unit.php?unit=MOOg%3B0)

Gasconade Dolomite (sgmc-unit.php?unit=MOOg%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 40 % of this area*

Coarse - crystalline cherty dolomite with a basal Gunter Sandstone Member.

(sgmc-unit.php?unit=MOCAep%3B0)

Eminence Dolomite, Potosi Dolomite (sgmc-unit.php?unit=MOCAep%3B0) (Late Cambrian-Croixian Series) *at surface, covers 7 % of this area*

Eminence Dolomite - dolomite with some druse - coated chert. Potosi Dolomite - dolomite with abundance of druse - coated chert.

(sgmc-unit.php?unit=MOpCAv%3B0)

St. Francois mountains volcanic supergroup (sgmc-unit.php?unit=MOpCAv%3B0) (Precambrian Y) *at surface, covers 0.5 % of this area*

Chiefly alkali rhyolitic ash - flow tuffs, lava flows, and bedded tuffs, with minor trachytes.

(sgmc-unit.php?unit=MOOjc%3B0)

Smithville Dolomite, Powell Dolomite, Cotter Dolomite, Jefferson City Dolomite (sgmc-unit.php?unit=MOOjc%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 0.3 % of this area*

Fine crystalline, silty, cherty dolomite, and oolitic chert with local sandstone beds.

(sgmc-unit.php?unit=MOpCAi%3B0)

St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes) (sgmc-unit.php?unit=MOpCAi%3B0) (Precambrian Y) *at surface, covers < 0.1 % of this area*

St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes).

Carter Ex 2

Reynolds 1 of 2

(https://www.usgs.gov/)

Geologic units in Reynolds county, Missouri

(sgmc-unit.php?unit=MOCAep%3B0)

Eminence Dolomite, Potosi Dolomite (sgmc-unit.php?unit=MOCAep%3B0)

(Late Cambrian-Croixian Series) *at surface, covers 61 % of this area*

Eminence Dolomite - dolomite with some druse - coated chert. Potosi Dolomite - dolomite with abundance of druse - coated chert.

(sgmc-unit.php?unit=MOOg%3B0)

Gasconade Dolomite (sgmc-unit.php?unit=MOOg%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 31 % of this area*

Coarse - crystalline cherty dolomite with a basal Gunter Sandstone Member.

(sgmc-unit.php?unit=MOCAeb%3B0)

Elvins Group - (including Derby-Doerun Dolomite, Davis Formation), Bonneterre Dolomite (sgmc-unit.php?unit=MOCAeb%3B0) (Late Cambrian-Croixian Series) *at surface, covers 4 % of this area*

Derby-Doerun Dolomite - alternating thin dolomite, siltstone, and shale; Davis Formation - glauconitic shale with fine - grained sandstone, limestone, and dolomite); Bonneterre Dolomite - dolomite, dolomitic limestone, and limestone; glauconitic in lower part.

(sgmc-unit.php?unit=MOpCAv%3B0)

St. Francois mountains volcanic supergroup (sgmc-unit.php?unit=MOpCAv%3B0) (Precambrian Y) *at surface, covers 3 % of this area*

Chiefly alkali rhyolitic ash - flow tuffs, lava flows, and bedded tuffs, with minor trachytes.

(sgmc-unit.php?unit=MOOr%3B0)

Roubidoux Formation (sgmc-unit.php?unit=MOOr%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 0.7 % of this area*

Sandstone, chert and interbedded dolomite

(sgmc-unit.php?unit=MOpCAi%3B0)

St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes) (sgmc-unit.php?unit=MOpCAi%3B0) (Precambrian Y) *at surface, covers 0.5 % of this area*

St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes).

(sgmc-unit.php?unit=MOpCAd%3B0)

Diabase dikes and sills (sgmc-unit.php?unit=MOpCAd%3B0) (Precambrian Y) *at surface, covers < 0.1 % of this area*

Diabase dikes and sills.

Washington 1 of 2

(https://www.usgs.gov/)

Geologic units in Washington county, Missouri

Additional scientific data in this geographic area (/catalog/science.php?thcode=1&term=f29221)

(sgmc-unit.php?unit=MOCAep%3B0)

Eminence Dolomite, Potosi Dolomite (sgmc-unit.php?unit=MOCAep%3B0)

(Late Cambrian-Croixian Series) *at surface, covers 51 % of this area*

Eminence Dolomite - dolomite with some druse - coated chert. Potosi Dolomite - dolomite with abundance of druse - coated chert.

(sgmc-unit.php?unit=MOOg%3B0)

Gasconade Dolomite (sgmc-unit.php?unit=MOOg%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 29 % of this area*

Coarse - crystalline cherty dolomite with a basal Gunter Sandstone Member.

(sgmc-unit.php?unit=MOCAeb%3B0)

Elvins Group - (including Derby-Doerun Dolomite, Davis Formation), Bonneterre Dolomite (sgmc-unit.php?unit=MOCAeb%3B0) (Late Cambrian-Croixian Series) *at surface, covers 10 % of this area*

Derby-Doerun Dolomite - alternating thin dolomite, siltstone, and shale; Davis Formation - glauconitic shale with fine - grained sandstone, limestone, and dolomite); Bonneterre Dolomite - dolomite, dolomitic limestone, and limestone; glauconitic in lower part.

(sgmc-unit.php?unit=MOOr%3B0)

Roubidoux Formation (sgmc-unit.php?unit=MOOr%3B0) (Early Ordovician-Ibexian Series) *at surface, covers 8 % of this area*

Sandstone, chert and interbedded dolomite

(sgmc-unit.php?unit=MOCAlm%3B0)

Lamotte Sandstone (sgmc-unit.php?unit=MOCAlm%3B0) (Late Cambrian-Croixian Series) *at surface, covers 1 % of this area*

Sandstone with some dolomitic and shaly lenses; coarse - graines to conglomeratic and arkosic at base.

(sgmc-unit.php?unit=MOpCAv%3B0)

Washington ? ?

St. Francois mountains volcanic supergroup (sgmc-unit.php?unit=MOpCAv%3B0) (Precambrian Y) *at surface, covers 1.0 % of this area*

Chiefly alkali rhyolitic ash - flow tuffs, lava flows, and bedded tuffs, with minor trachytes.

(sgmc-unit.php?unit=MOpCAi%3B0)

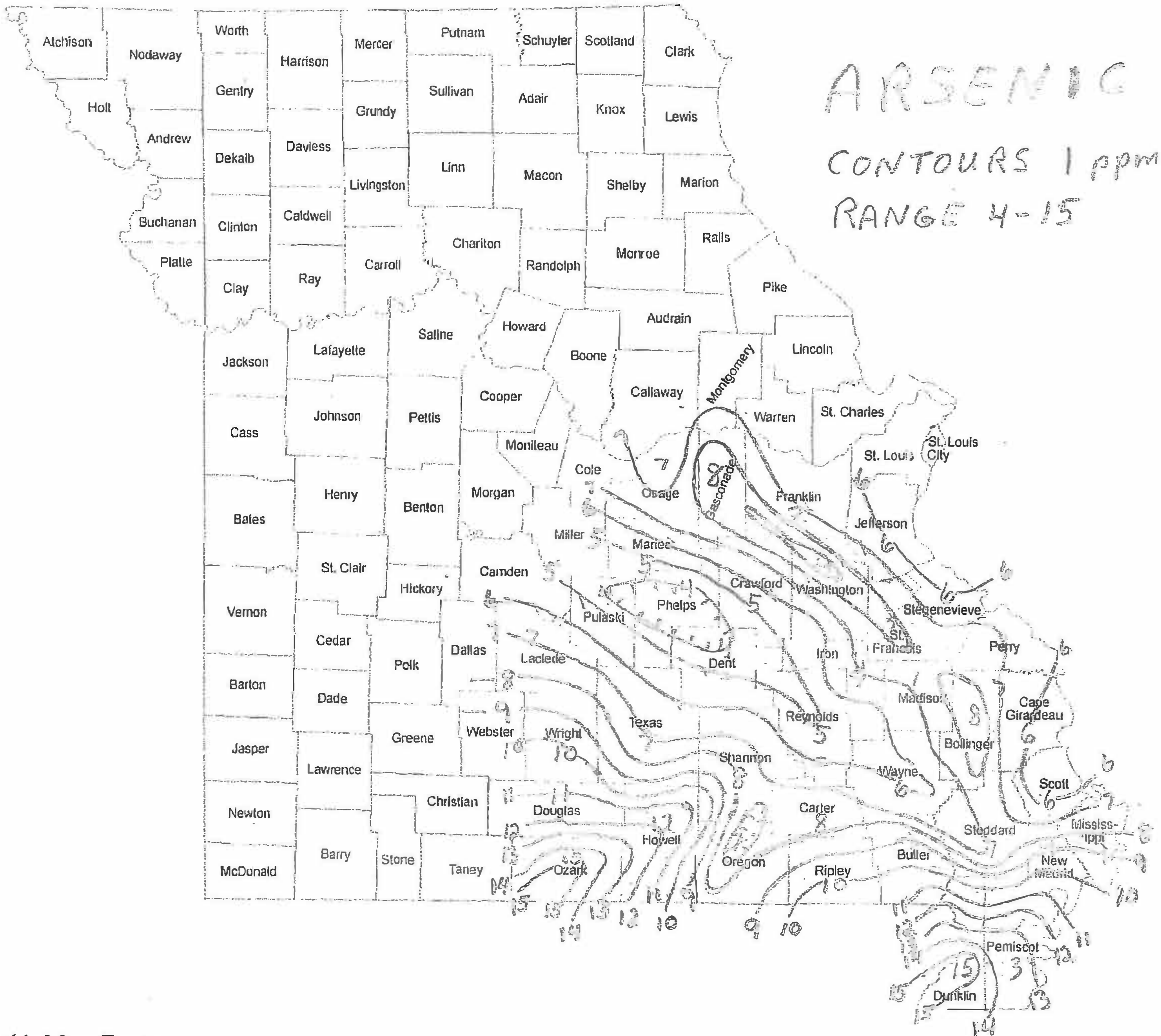
St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes) (sgmc-unit.php?unit=MOpCAi%3B0) (Precambrian Y) *at surface, covers 0.4 % of this area*

St. Francois Mountains intrusive suite (subvolcanic, alkali granitic ring complexes).

(sgmc-unit.php?unit=MOpCAd%3B0)

Diabase dikes and sills (sgmc-unit.php?unit=MOpCAd%3B0) (Precambrian Y) *at surface, covers < 0.1 % of this area*

Diabase dikes and sills.


ARSENIC
CONTOURS 1 ppm
RANGE 4-15
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Gentry
Sullivan
Adair
Knox
Lewis
Grundy
Andrew
Dekalb
Daviess
Linn
Macon
Shelby
Marion
Livingston
Buchanan
Clinton
Caldwell
Chariton
Randolph
Monroe
Ralls
Platte
Carroll
Clay
Ray
Pike
Howard
Audrain
Saline
Lafayette
Jackson
Boone
Lincoln
Montgomery
Callaway
Cooper
St. Charles
Warren
Johnson
Pettis
Cass
Moniteau
St. Louis City
St. Louis
Cole
Osage
Gasconade
Franklin
Henry
Morgan
Benton
Bates
Miller
Maries
Jefferson
St. Clair
Camden
Crawford
Washington
Hickory
Phelps
Pulaski
Ste. Genevieve
Vernon
Cedar
Dallas
Polk
Laclede
Dent
Iron
St. Francois
Perry
Barton
Dade
Madison
Cape Girardeau
Reynolds
Texas
Jasper
Greene
Webster
Wright
Bollinger
Lawrence
Shannon
Wayne
Scott
Christian
Douglas
Carter
Newton
Howell
Stoddard
Mississippi
Barry
Stone
Taney
Ozark
Oregon
Ripley
Butler
New Madrid
McDonald
Pemiscot
Dunklin

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COPPER
Contours 5 ppm
Range 7 - 17

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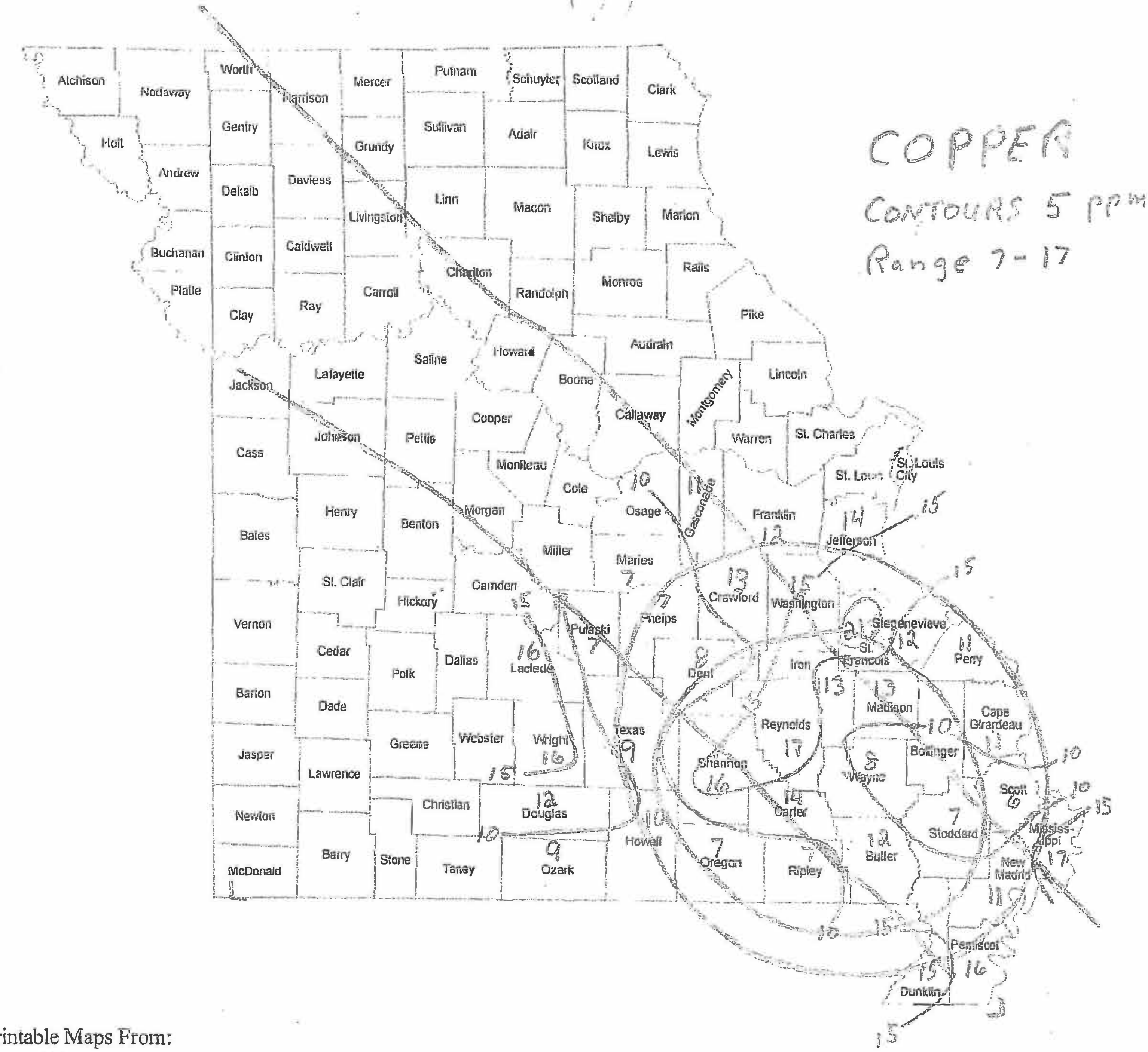

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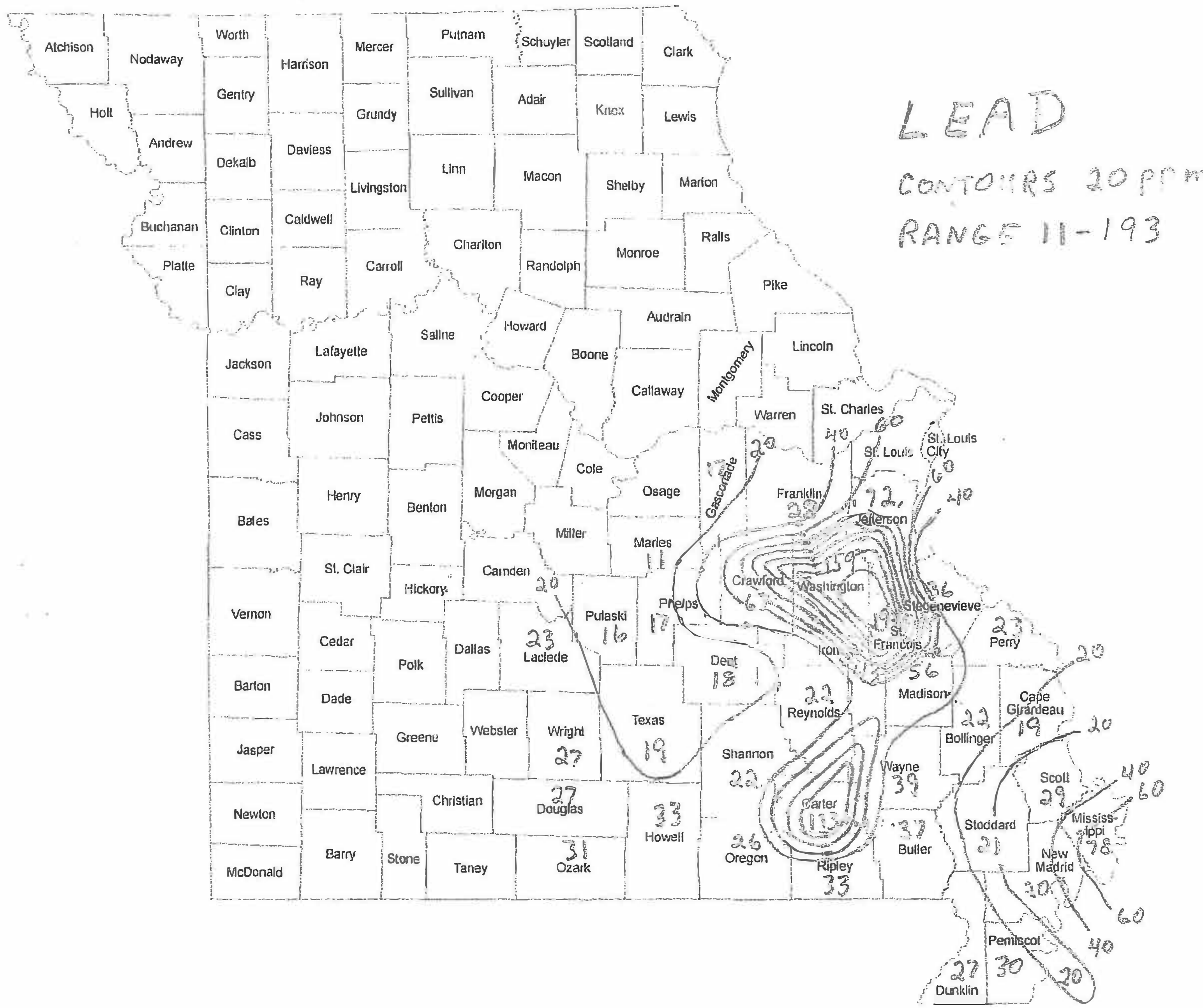

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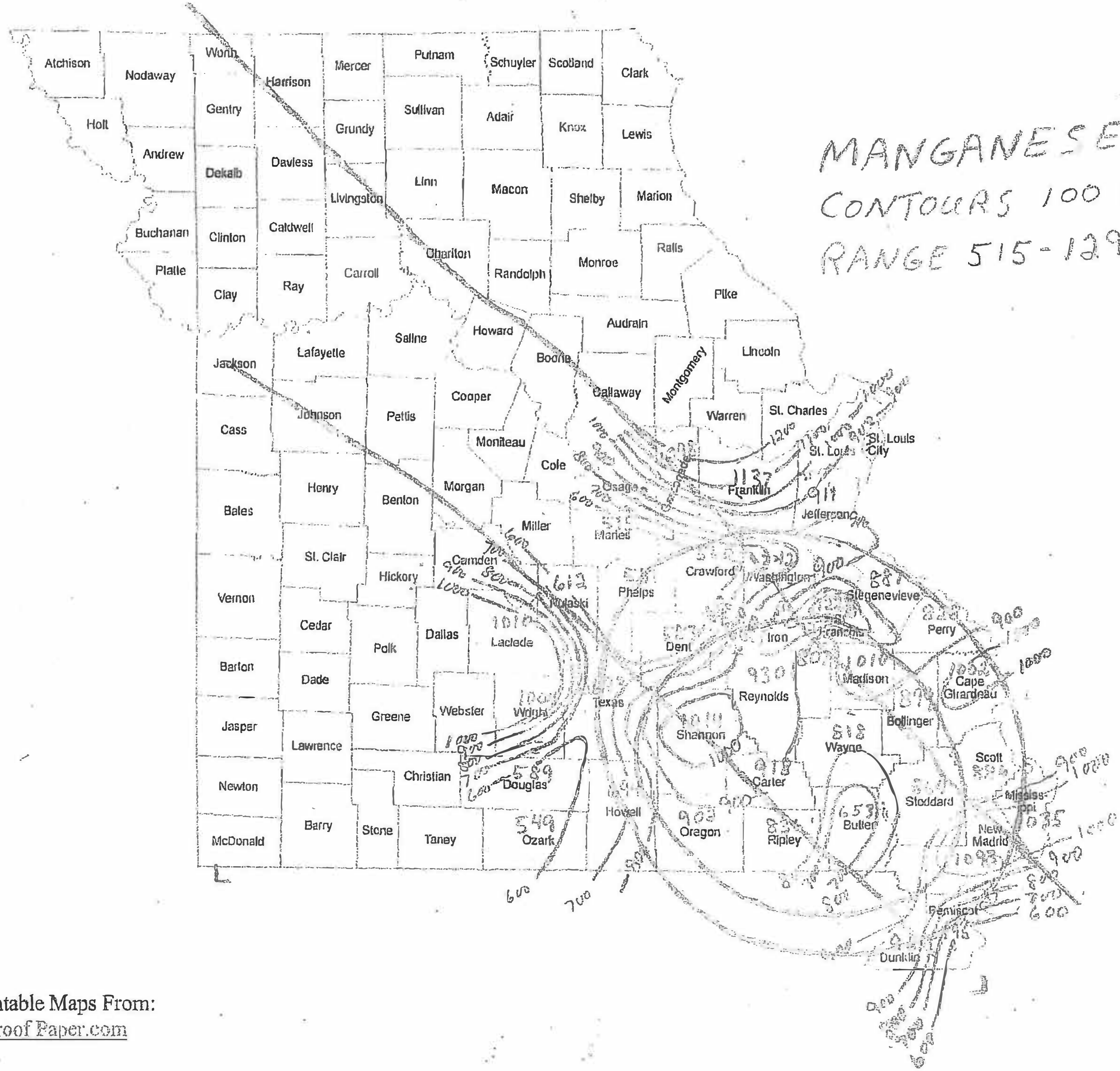
MANGANESE CONTOURS 100 PPM RANGE 515-1298

88

MANGANESE
CONTOURS 100 ppm
RANGE 515-1298



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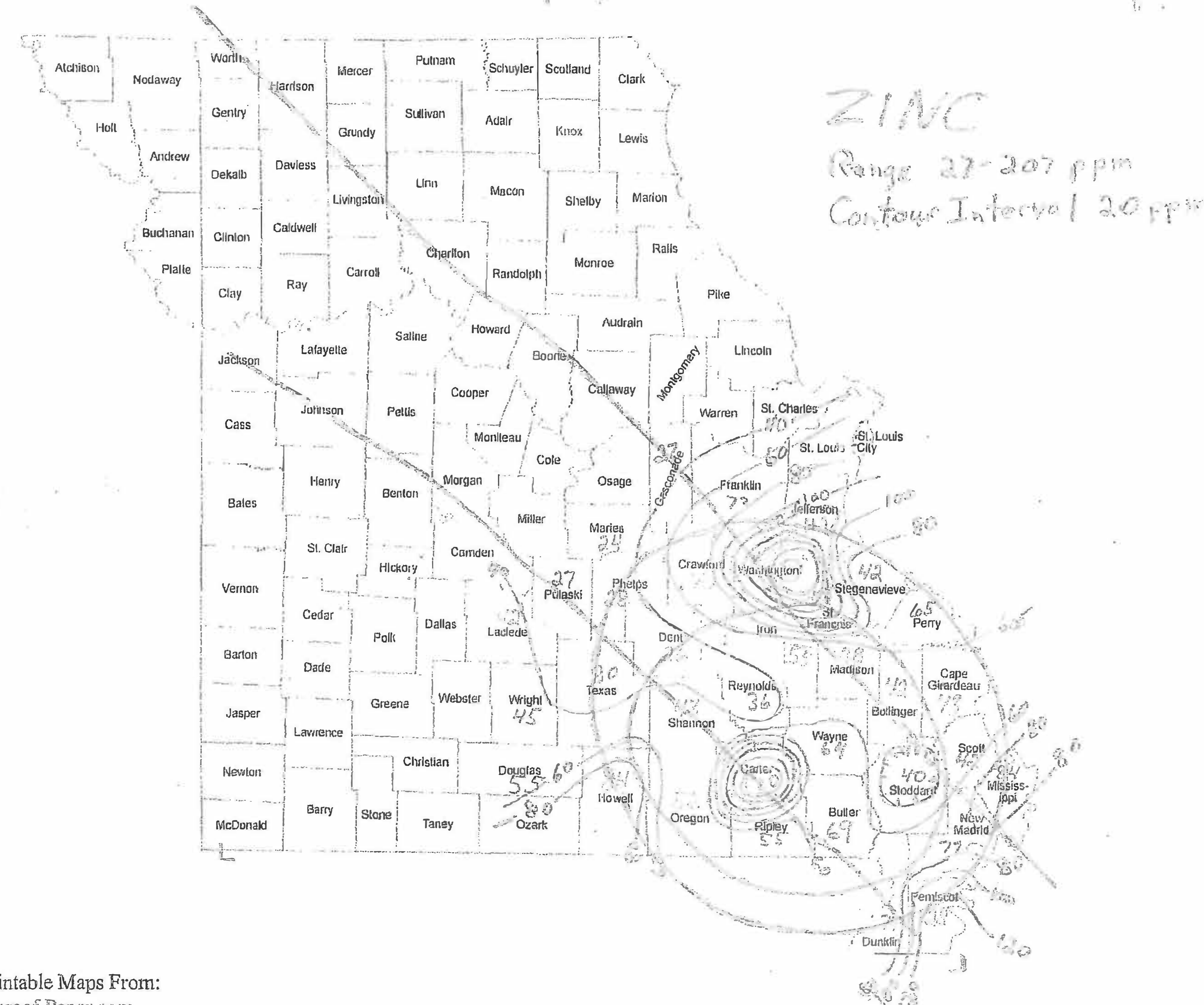
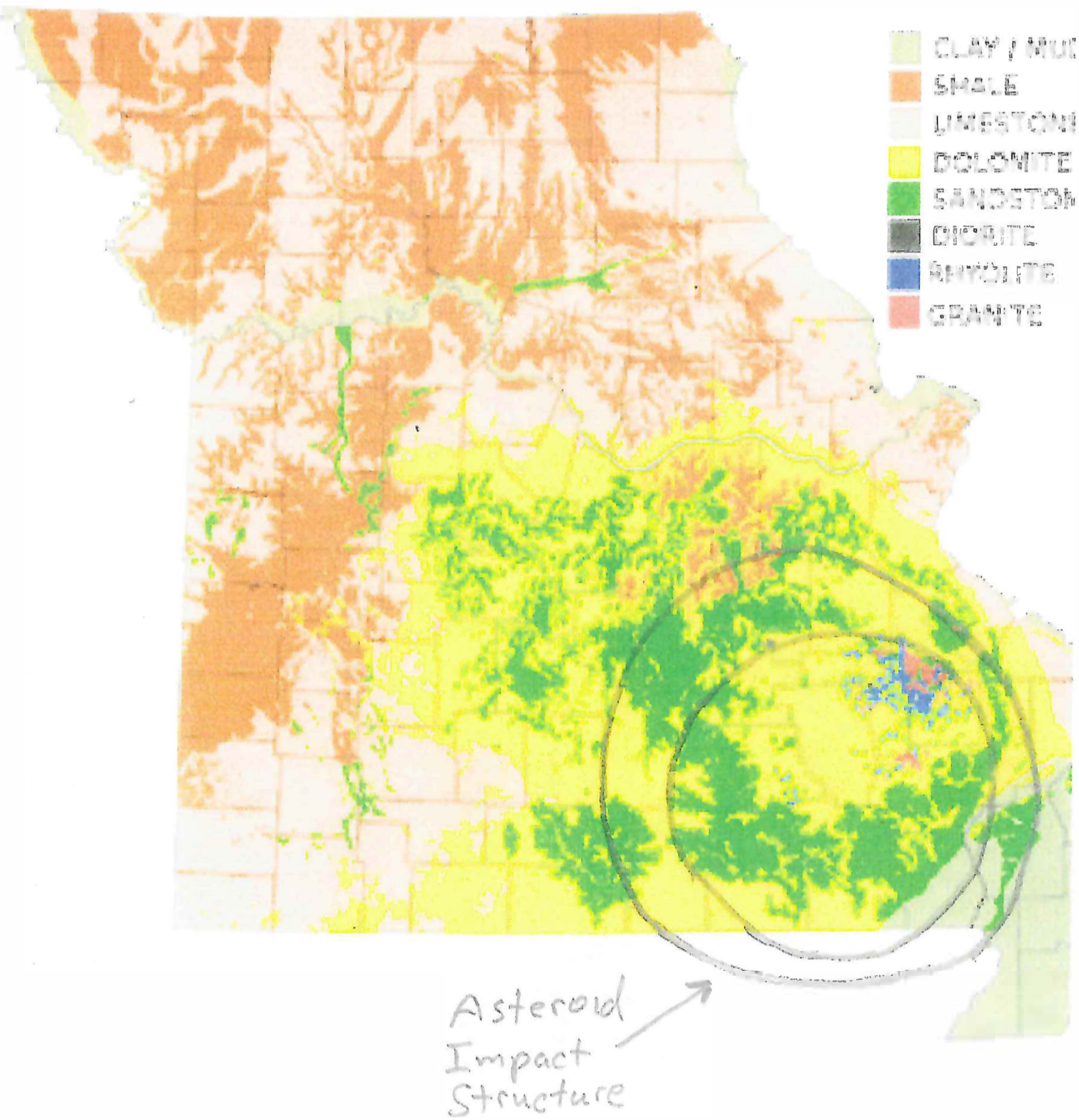
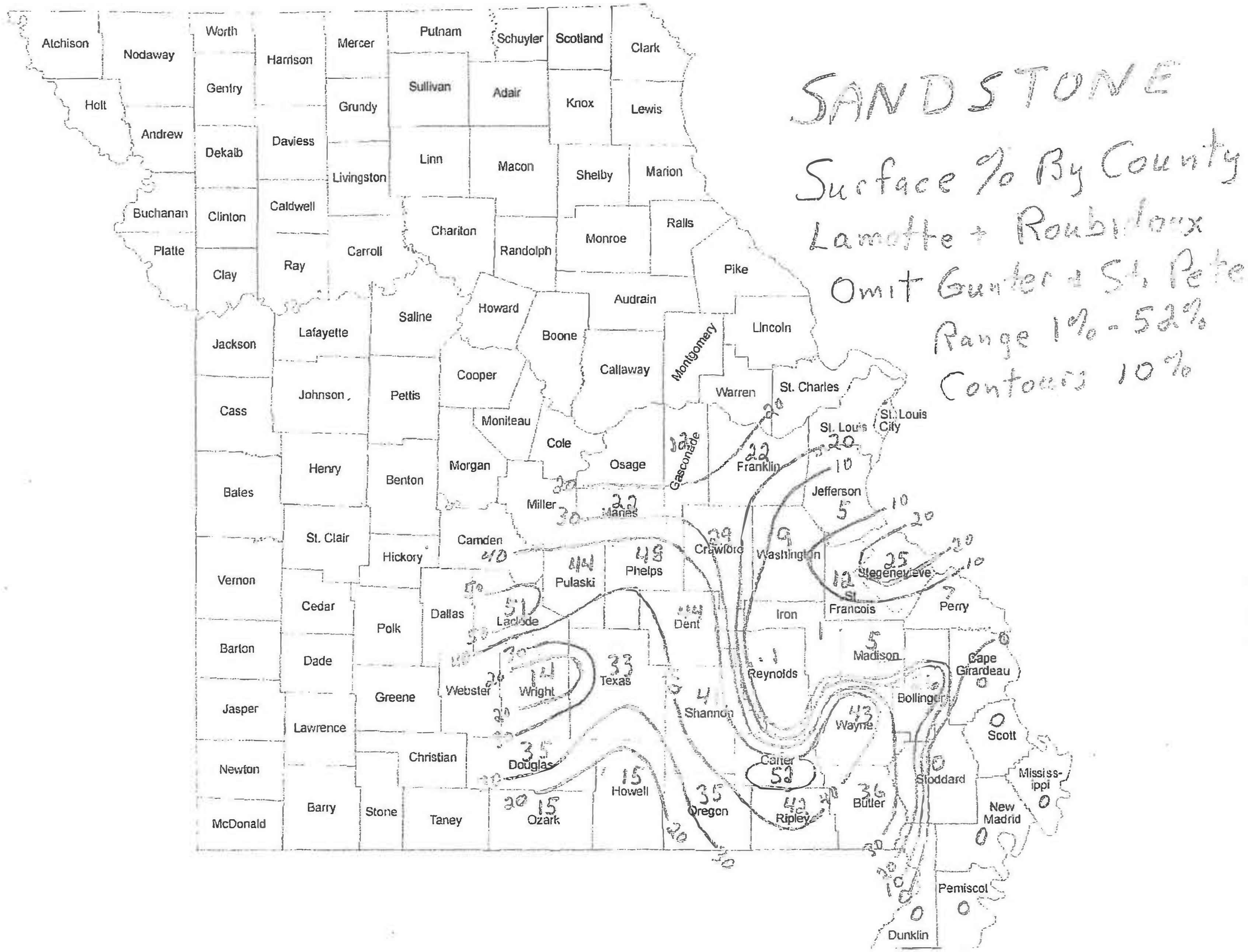
ZINC

Range 27-207 ppm
Contour Interval 20 ppm


ZINC
Range 27-207 ppm
Contour Interval 20 ppm
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Gentry
Grundy
Sullivan
Adair
Knox
Lewis
Andrew
Dekalb
Daviess
Linn
Macon
Shelby
Marion
Livingston
Buchanan
Clinton
Caldwell
Chariton
Randolph
Monroe
Ralls
Platte
Clay
Ray
Carroll
Pike
Howard
Audrain
Jackson
Lafayette
Saline
Boone
Lincoln
Montgomery
Callaway
Cooper
Cass
Johnson
Pettis
Warren
St. Charles
Moniteau
St. Louis
St. Louis City
Cole
Osage
Gasconade
Henry
Benton
Morgan
Franklin
Bates
Miller
Jefferson
Maries
St. Clair
Camden
Hickory
Crawford
Washington
Ste. Genevieve
Vernon
Pulaski
Phelps
Cedar
Perry
Dallas
Laclede
St. Francois
Polk
Iron
Dent
Barton
Dade
Madison
Cape Girardeau
Texas
Reynolds
Greene
Webster
Wright
Bollinger
Jasper
Shannon
Lawrence
Wayne
Scott
Christian
Carter
Newton
Douglas
Stoddard
Howell
Mississippi
Barry
Stone
Taney
Ozark
Oregon
Ripley
Butler
New Madrid
McDonald
Pemiscot
Dunklin



Sandstone - Green



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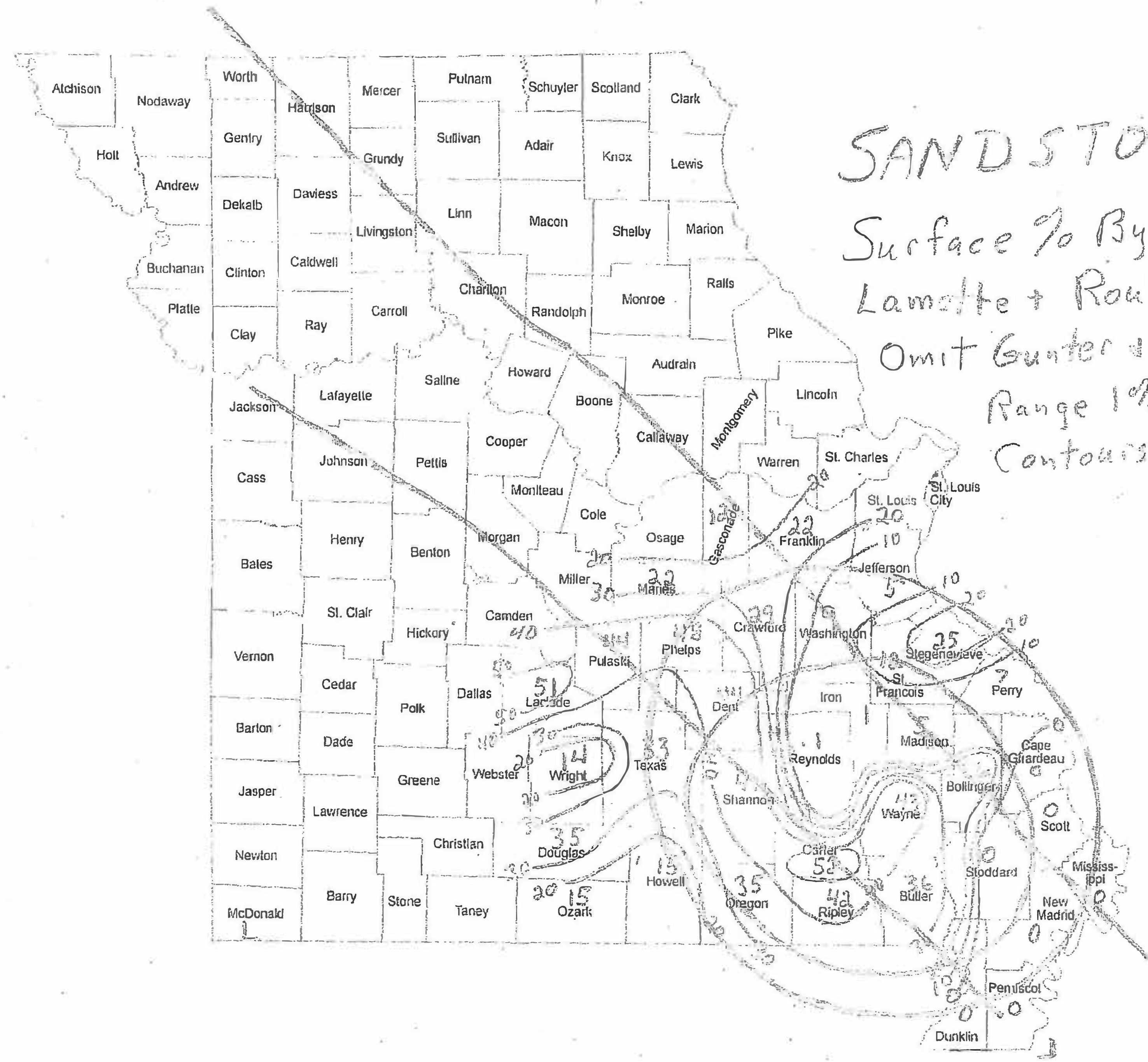
SANDSTONE

Surface % By County
Lamotte + Roubidoux
Omit Gunter + St. Peter
Range 1% - 52%
Contours 10%



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