DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
W. E. WRATHER, DIRECTOR

PREPARED IN COOPERATION WITH
THE STATE OF IOWA
GEOLOGICAL SURVEY

MINERAL INVESTIGATIONS
FIELD STUDIES MAP MF 42

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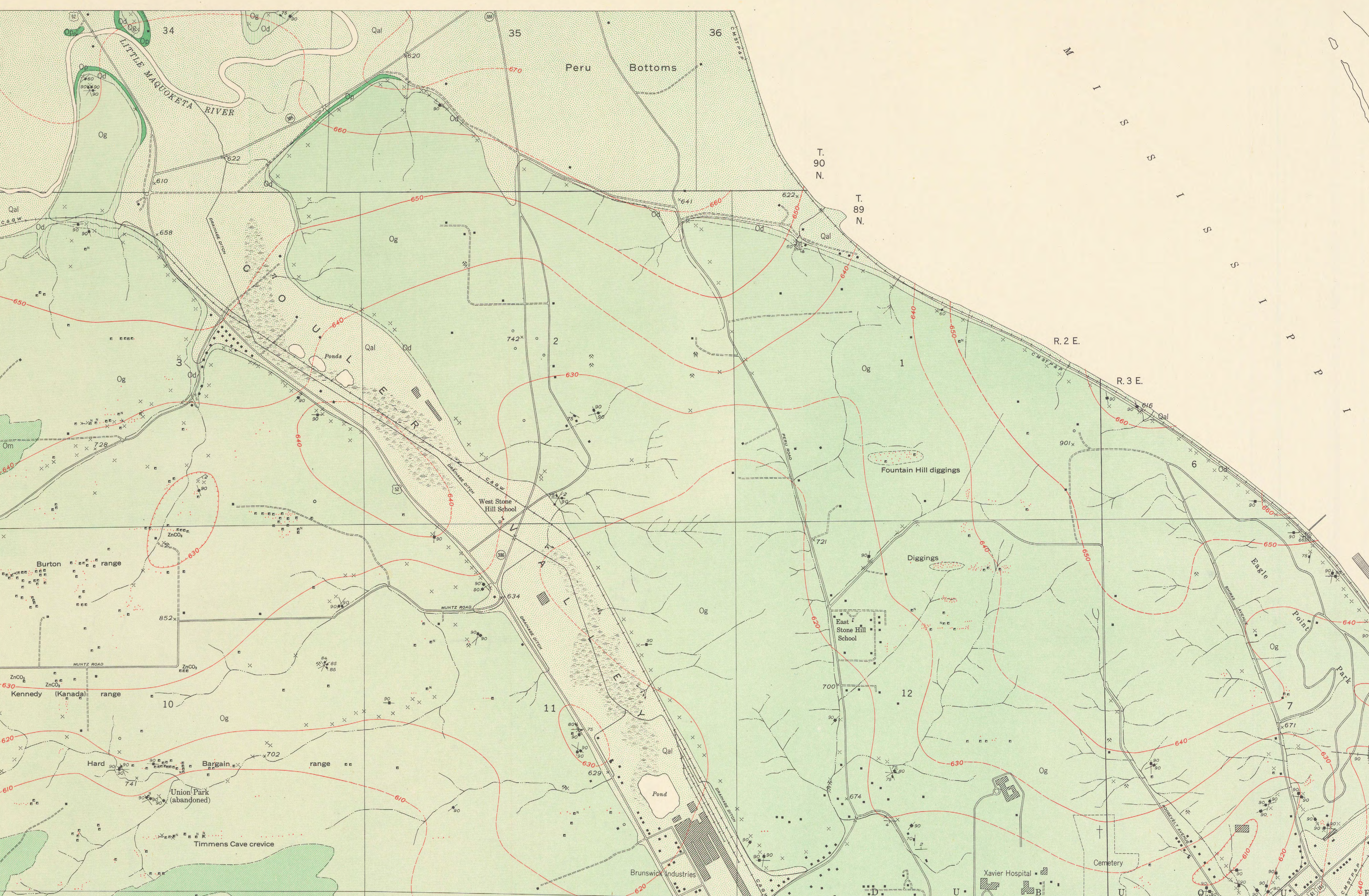

MAP SHOWING GEOLOGIC STRUCTURE AND ECONOMIC GEOLOGY OF THE COULER VALLEY AREA, DUBUQUE COUNTY, IOWA

Scale 1:12 000

1000 0 1000 2000 3000 4000 5000 Feet

Datum is mean sea level

EXPLANATION

QUATERNARY
- Qal — Alluvium

ORDOVICIAN
- Upper Ordovician: Om — Maquoketa shale
- Middle Ordovician: Og — Galena dolomite; Od — Decorah formation; Op — Platteville formation

Lead pits. *Dots are individual pits. Strike of "crevice" indicated by alinement of pits.*

Lead pits of irregular arrangement

Diggings — Area of concentrated lead diggings

Contact. *Dashed where inferred.*

Vertical fault, showing relative movement. *Dashed where inferred.*

Shear zone, showing dip

Strike and dip of beds

Strike and dip of joints

Strike of vertical joints

Strikes and dips of joints in multiple joint system

620 — 590 Structure contours on top of Decorah formation. *Long dash where control data are sparse, short dash where erosion has progressed below datum surface, hachured to indicate closed basin. Contour interval is 10 feet.*

Lead mine or prospect shaft, caved

Lead mine or prospect shaft, not caved. *Inactive or abandoned.*

Lead adit, open

Lead adit, closed

Quarry

Drill hole not intersecting zinc or lead ore

Outcrop points used for structural control

×857 Spot elevation

ZnCO₃: Zinc carbonate — Abbreviation for material present on mine dump

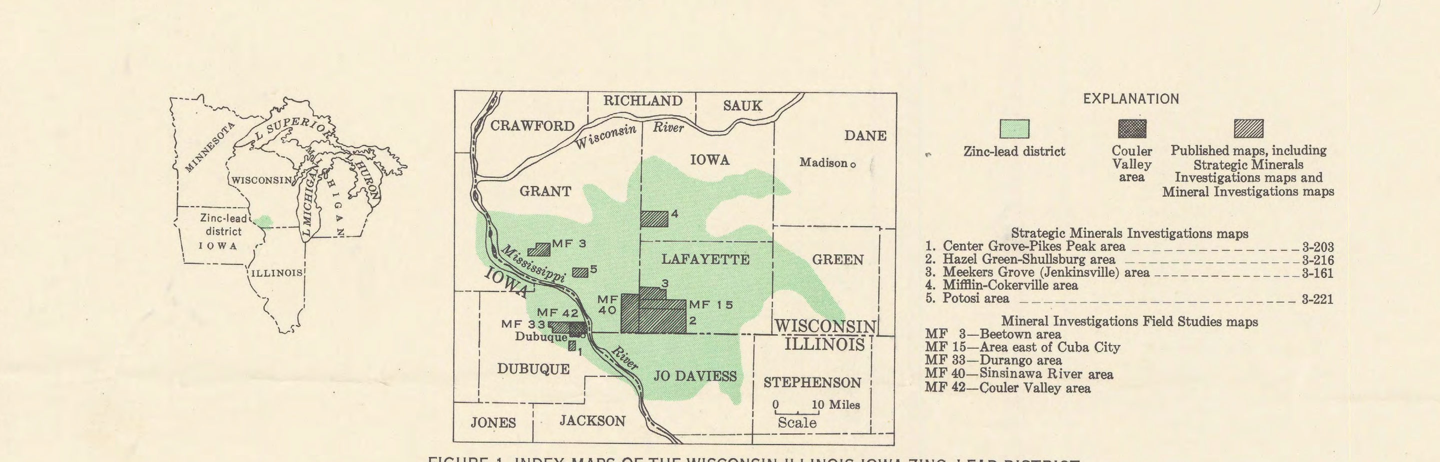

FIGURE 1. INDEX MAPS OF THE WISCONSIN-ILLINOIS-IOWA ZINC-LEAD DISTRICT

Series	Formation	Member	Local term	Lithology	Thickness in feet
PLEISTOCENE AND RECENT			Surface	Loess and residuum.	0-40
UPPER ORDOVICIAN	Maquoketa		Slate	Shale, dark-brown, soft, silty.	60+
				Shale as above; limestone, dolomitic, buff and gray, very argillaceous, medium granular; depauperate fauna and phosphatic nodules at base.	
MIDDLE ORDOVICIAN	Galena	Dubuque (Noncherty unit)	Yellow sandy	Dolomite, yellow-buff, medium granular; interbedded thin buff and purple-brown dolomitic shale; *Lingula iowensis.*	35
		Stewartville (Noncherty unit)	Buff	CAP ROCK UNIT FIRST OPENING* Dolomite, buff, medium crystalline, porous, massive.	36
				SECOND OPENING* Dolomite as above. Upper *Receptaculites* zone.	19
				Dolomite as above. THIRD OPENING*	27 (Noncherty unit 117)
		Prosser (Cherty unit)	Drab	UPPER FLINT OPENING* Dolomite as above; abundant bands of chert lower 17 feet.	23
				Dolomite as above, partly dense and siliceous; chert common; LOWER FLINT OPENING* *Receptaculites* lower 8 feet.	15
				Dolomite, dense, fine-grained, grayish-yellow; chert common.	7
				Dolomite, buff, medium-grained, massive; chert sparse; *Receptaculites* upper 9 feet.	22
				Dolomite, buff, fine-grained; chert common.	7
				Dolomite, buff, medium crystalline; no chert; *Receptaculites* common.	14
				LOWER RECEPTACULITES OPENING* Dolomite, as above; chert abundant; *Receptaculites* upper 9 feet.	17
				Dolomite, buff, coarse-grained, porous; no chert.	11 (Cherty unit 116; Galena 233)
	Decorah	Ion	Gray Blue	Limestone, gray with dark-gray specks, medium crystalline; blue-green shale partings.	20
		Guttenberg	Oil rock	Limestone, buff to brown, fine-grained, dense, fossiliferous; dark-brown carbonaceous shale partings.	17
		Spechts Ferry	Claybed	Shale, green, soft; dense gray limestone; phosphatic nodules.	8 (Decorah 45)
	Platteville	Quimbys Mill	Glass rock	Limestone, brown, granular; dark-brown shale.	0-0.5
		McGregor	Trenton	Limestone, gray, fine to medium crystalline, argillaceous, fossiliferous; gray shale.	32
		Pecatonica		Dolomite, light-brown, medium granular; phosphatic nodules and quartz sand at base.	24
		Glenwood		Shale, grayish-green; coarse subrounded quartz sand.	3-4 (Platteville 59-60.5)
	St. Peter			Sandstone, quartz, subrounded, fine to coarse, poorly cemented.	40+

* Openings are joints enlarged by solution. They commonly occupy the same stratigraphic positions and contain lead ore in many places throughout the zinc-lead district of Wisconsin, Illinois, and Iowa.

FIGURE 2. STRATIGRAPHIC SECTION OF THE MIDDLE AND UPPER ORDOVICIAN ROCKS EXPOSED IN DUBUQUE COUNTY, IOWA

GEOLOGY AND ZINC-LEAD DEPOSITS IN THE COULER VALLEY AREA, DUBUQUE COUNTY, IOWA

By

C. Ervin Brown, Lorence G. Collins, and Percy Crosby

INTRODUCTION

Geologic investigations were begun in the Iowa portion of the Wisconsin-Illinois-Iowa zinc-lead district to appraise its potentialities: (1) for zinc ore in strata that elsewhere in the mining district contain large zinc ore bodies and (2) for lead and zinc deposits of the type that were mined extensively in Dubuque County, Iowa, during the 19th century.

The Couler Valley area (fig. 1) adjoins Dubuque on the northwest and includes a small part of that city. Couler Valley, an abandoned valley of the Little Maquoketa River, extends northwestward across the area. The geologic map of the Couler Valley area is the second in a series prepared by the U. S. Geological Survey in cooperation with the Iowa Geological Survey. Adjoining the Couler Valley area on the west is the Durango area, discussed in the first report under this cooperative program (Flint and Brown, 1955).

The base map was prepared from aerial photographs taken in 1940 by the U. S. Department of Agriculture and from an unpublished section-corner survey made by the Federal Works Progress Administration prior to 1939. Vertical control was obtained from benchmarks along U. S. Highways 52, 61, and 151 and from U. S. Geological Survey benchmarks.

Field work consisted of examining all bedrock exposures, mines, and prospect pits (1) to determine their stratigraphic positions, (2) to take measurements of the structures, (3) to find evidence of mineralized rock, and (4) to record the type of deposit. Altitudes of key horizons were surveyed with a plane table and alidade. A transit was used for high-angle surveying along the bluff of the Mississippi River.

This report is based on field work begun in May 1953 and completed in October 1953. The authors are grateful for the assistance of members of the Dubuque County Engineer's office in supplying highway altitudes, and of John Tyndale and John Finch of the Topographic Division of the U. S. Geological Survey for supplying pertinent altitudes along level lines as they were being run. Acknowledgment is also made to the Dubuque Well Drilling Co. for logs of wells drilled in this vicinity.

HISTORY AND PRODUCTION

Active mining of the lead ore galena in the Couler Valley area began in 1788, when Julien Dubuque befriended the Fox Indians and acquired mining rights to an area between Tete des Morts Creek and the Little Maquoketa River from the Spanish governor of the land west of the Mississippi River. Dubuque's concession included most of the present Couler Valley area. After Dubuque's death in 1810, mining in "the mines of Spain," as they were then called, was continued by Indians, who traded their lead ore to a group of white men who had built a smelting furnace nearby on one of the islands in the Mississippi River. In 1833 the territory west of the Mississippi River was opened for settlement, and lead mining was resumed by immigrants from Illinois and Wisconsin. From 1833 until 1846 or 1847, lead mining increased steadily; after 1847 it leveled off until 1857, when lead output began to decrease. Except for brief spurts in 1887-1888 and in 1905-1907 the drop in production continued until 1910, when the last of the large mines in Iowa was shut down. Since that date sporadic mining by only a few small operators has produced an insignificant tonnage of lead ore.

Zinc and lead deposits in Iowa were mined from solution-widened vertical joints. These mineralized joints were called "crevices" by the early miners, and closely spaced parallel crevices were named "ranges." Whitney (1858, p. 432) introduced the term "gash vein" for these joint-controlled deposits.

Zinc, first recovered about 1860, has never been as important as lead in Iowa. The zinc carbonate smithsonite was the dominant ore mineral, but some of the zinc sulfide sphalerite was also mined.

Accurate figures for lead and zinc production are not available for the Dubuque part of the mining district; however, estimated figures for the different ranges and crevices in the Couler Valley area have been included in earlier geological reports on the Iowa portion of the zinc-lead district (table 1).

TABLE 1.—PRODUCTION FROM RANGES AND CREVICES IN THE COULER VALLEY AREA

Name of range or crevice [1]	Location	Reported production in pounds of galena
T. 89 N., R. 2 E.		
Burton	N½N½ secs. 9 and 10	[2]4,000,000
Kanada (Kennedy)	S½N½ secs. 9 and 10	[2]2,000,000
Hard Bargain	N½S½ secs. 9 and 10	[2]1,000,000
Stewart and Bartlett	N½N½ sec. 15	[2]5,500,000
Sunflower	S½S½ secs. 14 and 15	2,000,000
Dubuques Cave	S½S½ secs. 14 and 15	2,000,000
Levens (North Langworthy)	S½S½ secs. 14 and 15	[2]10,000,000 to 15,000,000

[1] For a description of range or crevice see Calvin and Bain (1900, p. 530-536 and 599); some are also mentioned in reports by Owen (1840), Whitney (1858), and Leonard (1897).
[2] Part of this production came from outside the Couler Valley area.

STRATIGRAPHY

The geologic map shows the areal distribution of bedrock. The names, lithologies, and thicknesses are given in figure 2.

Platteville formation.—The Platteville formation, which is the lowest stratigraphic unit pertinent to this investigation, is exposed along the Little Maquoketa River in the SW¼ sec. 34, T. 90 N., R. 2 E., and also along State Route 386 in the SW¼ sec. 35, T. 90 N., R. 2 E. Drilling indicates that the formation is about 60 feet thick in the Couler Valley area. The basal Glenwood shale member and the Pecatonica dolomite member are not considered good host rocks for ore because elsewhere in the zinc-lead district only small amounts of disseminated sphalerite and galena have been found in them. Overlying the Pecatonica is the McGregor limestone member (Trenton of local usage), which contains zinc ore in some of the Wisconsin mines. The McGregor member therefore should be considered as a potentially productive rock for zinc ore in the Couler Valley area until proved otherwise.

The Quimbys Mill member (glass rock of local usage), which is the uppermost member of the Platteville formation, is not exposed in the mapped area and has not been recognized in drill cuttings. If it is present at all, it is less than half a foot thick, as in the Durango area just to the west (Flint and Brown, 1955).

Decorah formation.—Overlying the Platteville formation is the Spechts Ferry shale member (clay bed of local usage) of the Decorah formation. In the Couler Valley area the Spechts Ferry member is poorly exposed along the west side of U. S. Highway 52 in the SW¼ sec. 34, T. 90 N., R. 2 E., and along the Mississippi River bluff. It is an unfavorable host rock for zinc or lead ore in the mining district, but some disseminated lead and zinc sulfides are found in the Spechts Ferry member.

Overlying the Spechts Ferry shale member is the Guttenberg limestone member (oil rock of local usage), which elsewhere in the district is a host rock for zinc ore. In Iowa it has not been explored adequately to determine whether it contains zinc and lead ore. In the Couler Valley area the Guttenberg limestone member crops out at several places. Its full thickness of 17 feet is exposed in a gully on the John Deere experimental farm in the SW¼SW¼ sec. 35, T. 90 N., R. 2 E. Another good exposure is along the west side of U. S. Highway 52 in the NW¼SE¼ sec. 3, T. 89 N., R. 2 E. Leaching and compaction have locally reduced the thickness of the Guttenberg member as much as 75 percent. This type of altered Guttenberg is exposed in the south wall of the abandoned quarry of the Eagle Point Lime Works in the NE¼SE¼ sec. 7, T. 89 N., R. 3 E., where it is represented by 5 feet of dark-brown carbonaceous shale and a buff coarse-grained crystalline dolomite.

The uppermost unit of the Decorah formation is the Ion dolomite member, which in the Couler Valley area is limestone and shale. This unit is an important host rock for zinc ore in the mining district. Local miners and drillers divide the Ion member into two subordinate units, naming the upper part the gray beds and the lower part the blue beds. The characteristic color of the blue beds is due to the great abundance of bluish-green shale partings in the lower 7 feet of the Ion member. The thickness of the Ion is normally 20 feet, but locally leaching and compaction may have reduced its thickness. The member is exposed in the quarry at Eagle Point, and the full thickness crops out in the Mississippi River bluffs just west of the U. S. Corps of Engineers dam and lock 11 in the SE¼ sec. 7, T. 89 N., R. 3 E.

Galena dolomite.—The Galena dolomite overlying the Decorah formation is an important host rock for both zinc and lead deposits and forms bluffs in the Couler Valley area. The lower half of the formation contains numerous bands of nodular chert, which make possible a convenient subdivision of the Galena dolomite into the Cherty and Noncherty units. The upper 35 feet of the Noncherty unit—the thin-bedded Dubuque member—does not form bluffs; however, it is well exposed in quarries in the SW¼SW¼ sec. 14, T. 89 N., R. 2 E., north of Kaufmann Avenue, where it is being quarried for dimension stone.

The Galena is normally a crystalline dolomite; however, in an area including most of sec. 11, T. 89 N., R. 2 E., located within the broad anticline along the southwest side of Couler Valley, the basal 30 feet is tan fine-grained limestone with reticulated patches of dark-brown earthy to finely crystalline dolomite.

Maquoketa shale.—The Maquoketa shale is not exposed in the Couler Valley area. Its presence in the area was determined by shale float, shale on mine dumps, and records from drill holes. The drill-hole data were used for structural control, because the Maquoketa shale-Galena dolomite contact is easily distinguished in drill-hole cuttings.

There is no evidence of commercial deposits of lead or zinc in the Maquoketa shale; however, sphalerite and pyrite occur in the lower 2 to 3 feet of the formation.

Quaternary deposits.—The youngest deposits in the area are the sand and gravel of Wisconsin age, which form the valley fill of the Couler Valley, Little Maquoketa Valley, and the Peru Bottoms along the Mississippi River. Remnants of river terraces were observed as high as 60 feet above water level at the mouth of the Little Maquoketa River. These deposits have been excavated in the Peru Bottoms for road material and concrete aggregate. At present gravel and washed sand are being taken from the valley fill in Couler Valley. In a well at the West Stone Hill School in the SE¼SW¼ sec. 2, T. 89 N., R. 2 E., 95 feet of these sands and gravels were penetrated, and a well at Leiser's tavern in the SW¼NW¼ sec. 34, T. 90 N., R. 2 E. (800 feet north of the U. S. Highway 52 bridge over the Little Maquoketa River), was drilled through 120 feet of sand and gravel. Both drill holes entered St. Peter sandstone below the valley fill; therefore, in the Couler Valley area most of the potential ore-bearing formations have been cut away in the valleys now filled with fluvioglacial material.

ROCK ALTERATION

Alteration of the country rock adjacent to zinc and lead deposits in the mining district is due to (1) leaching, (2) dolomitization, and, less commonly, (3) silicification. Evidence of leaching only is conspicuous near the crevice lead and zinc deposits in the Galena dolomite, but evidence of all three processes has been observed in the large zinc deposits of the Decorah formation and the lower part of the Galena dolomite in Wisconsin and Illinois.

Leaching in the vicinity of the crevice deposits in the Galena dolomite by waters mainly below the water table has reduced the massive crystalline dolomite along crevices to dolomite sand and residual clay, which remain in the crevices. Evidence is present of leaching before and after ore deposition, and the pre-ore leaching was partly responsible for the localization of the zinc and lead deposits in crevices.

Leaching and contemporaneous compaction in the Decorah formation have reduced the shaly limestone of the lower part of the Ion member and the entire Guttenberg member to a residue of shales, blue and dark brown respectively. Unlike the leaching in the Galena dolomite, that in the Decorah strata is not confined to fractures but extends laterally through the rocks. In the quarry at Eagle Point the Guttenberg member is exposed, thinned to approximately one-third its normal thickness (see Decorah formation); exposures in a small gully along the Mississippi River bluffs just west of the U. S. Corps of Engineers dam 11 also show the results of such thinning. These two outcrops are 1,900 feet apart, and the thinning by leaching and compaction possibly has been effected continuously between them.

Dolomitized strata of the Ion and Guttenberg members, which are normally sublithographic to finely granular limestones, are commonly found where these members are leached. In the quarry at Eagle Point the two members are dolomitized and have a sugary texture.

Silicification of the Decorah formation has been noted around ore bodies elsewhere in the zinc-lead district, but it was not seen in the Couler Valley area.

STRUCTURE

The regional dip in the vicinity of Dubuque, Iowa, is southwestward 15 to 20 feet per mile, but in the Couler Valley area the average dip is southwestward 25 to 30 feet per mile. Locally, as in sec. 7, T. 89 N., R. 3 E., the dip is as much as 50 feet per mile.

Superimposed on the regional dip are several small anticlines and synclines that have resulted from lateral compressive forces. These folds vary in width and structural relief from broad, open folds as in sec. 11, T. 89 N., R. 2 E., to relatively tight folds such as the northeast-trending syncline in the SW¼ sec. 7, T. 89 N., R. 3 E. In the mapped area these folds all trend northeastward or northwestward except for the east-trending, elongate syncline in the NE¼ sec. 15, T. 89 N., R. 2 E., which possibly is due to solutional softening and subsequent slumping of the rocks along mineralized crevices.

The rocks of the Couler Valley area are characterized by a well-developed joint system. Most joints are vertical, but some dip as little as 60°. The most prominent joint set strikes S. 70° E. to N. 80° E., and the next most common joints strike N. 10°-20° W., and N. 20°-60° E.

Faults are not conspicuous and have been observed in only a few places in this area. A fault zone in the quarry at Eagle Point has a total vertical displacement of 4 feet and a horizontal displacement of more than 19 feet. The fault surfaces strike N. 85° W., parallel to the major joint set. Other faults observed in this area occur along mineralized crevices. Their displacements are minor and possibly are due to slumping along joints.

ORE DEPOSITS

Composition of the ores.—Ore deposits in the Couler Valley area, as in the rest of the zinc-lead district, are mineralogically simple (table 2).

TABLE 2.—MINERALS OF ORE DEPOSITS IN THE COULER VALLEY AREA

Mineral	Chemical composition	Local terms
Ore minerals		
Galena	Lead sulfide	Lead or mineral.
Sphalerite	Zinc sulfide	Jack or black jack.
Smithsonite	Zinc carbonate	Drybone or bone.
Associated minerals		
Cerussite	Lead carbonate	
Pyrite	Iron sulfide	Sulfur.
Marcasite	Iron sulfide	Sulfur.
Limonite	Hydrous iron oxide	Ocher.
Malachite	Basic copper carbonate	
Calcite	Calcium carbonate	Tiff or spar.
Dolomite	Calcium-magnesium carbonate	
Chert	Silicon dioxide	Flint.
Barite	Barium sulfate	Barytes.

Galena is now (1954) the only lead mineral of commercial importance and sphalerite is the only economically valuable zinc mineral. Smithsonite had commercial importance and was recovered in the Couler Valley area until about 1910. Pyrite and marcasite occur with the lead and zinc deposits. Limonite is present as an oxidation product of the iron sulfides. Malachite and barite have been found only in trace quantities in the Couler Valley area.

Occurrence of ore minerals.—The lead-ore mineral galena commonly occurs in large irregular pieces known as chunk lead and in aggregates of large crystals known as cog lead. Galena less commonly forms small individual crystals or aggregates of crystals known as dice mineral and veins called sheets. Above the water table the galena has a surface coating of the lead carbonate cerussite.

Sphalerite occurs as disseminated crystals in vugs within the rock, as veins, and as fracture and breccia fillings. It commonly displays dodecahedral crystal faces if it has grown in a cavity.

The zinc carbonate smithsonite, an alteration product of zinc sulfide, is produced by exposure of sphalerite to oxidation at and above the water table. The zinc carbonate smithsonite is pseudomorphic after sphalerite, which still composes the cores of some crystals. The interior of the smithsonite is very porous, resembling the internal structure of dried bones, hence the name drybone. Zinc carbonate also occurs as drab-colored masses, which probably result from transportation and redeposition. This type of smithsonite is called rock bone by local miners. In this mining district zinc carbonate is stained an iron-rust color by the abundant limonite or ocher; however, fresh surfaces range from light gray to tan.

Pyrite and marcasite occur with the sphalerite deposits and in lesser amounts with the galena deposits. Above the water table the iron sulfides oxidize to limonite, which is usually a powdery ocher.

Lead deposits.—Primary localization of lead deposits in the Galena dolomite was controlled by three factors: (1) limited stratigraphic zones of greater solubility, (2) vertical or nearly vertical fractures intersecting those zones, and (3) intersections of two or more fractures. Water percolating along the fractures dissolved parts of the more soluble beds and created open spaces in which galena was deposited.

The trends of the principal crevices in the Couler Valley area are within a few degrees of east. The Patch diggings in the SE¼SE¼ sec. 14, T. 89 N., R. 2 E., are in a group of minor crevices oriented N. 30° E. These crevices lie between two well-defined ranges.

The main ore bodies in the numerous crevices or ranges indicated on the map occur in several stratigraphic positions. At these positions solution by ground water produced voids, called openings by the local miners, into which the ore was emplaced. The names and stratigraphic positions of the solution openings are listed in table 3.

TABLE 3.—NAMES AND STRATIGRAPHIC POSITIONS OF THE SOLUTION OPENINGS

Opening	Average depth, in feet, below the top of the Galena dolomite: Top of opening	Floor of opening
First (Cap rock)	35	41
Second (upper *Receptaculites*)	64-72	74-80
Third	105	110
Upper flint	119	130
Lower flint	152	156
Lower *Receptaculites*	205	210

The first opening in the Couler Valley area, as elsewhere in the vicinity of Dubuque, has been mined more extensively than the other openings. From it has come most of the production from Dubuques Cave, Levens range, and the Timmens Cave. The opening is in a zone of lithologic change from even-bedded shaly dolomite above to massive crystalline dolomite below. This opening has a cap-rock stratum whose stratigraphic position is easily recognized because of the consistent thicknesses of the individual beds below the cap rock even in outcrops where the opening is not developed. The cap rock, which is 3.2 feet thick, is underlain in descending order by a 0.5-foot bed and a 1.7-foot bed. The 0.5-foot bed is separated from the overlying and underlying beds by thin shale layers; erosion of these shale layers allows the 0.5-foot bed to be cut back, forming a reentrant that is very distinctive in outcrop. Subordinate planes of stratification may appear in the 3.2-foot bed where it is highly weathered, but normally it is massive.

The second opening commonly is in the upper *Receptaculites* zone, which extends from 36 to 55 feet below the base of the cap rock of the first opening. This opening is developed in or near beds that are not easily recognizable by lithologic characteristics but that can be identified by this fossil.

The third opening, from which much of the lead was mined in the Durango area, is 7 to 12 feet above the top of the Cherty unit. This opening is probably the one locally marked by a prominent layer of bentonite near Galena, Ill., 15 miles to the east.

The upper flint opening lies in the upper 10 feet of the very cherty dolomite at the top of the Cherty unit. This stratigraphic zone is ocherous and commonly shows the effects of solution, regardless of the proximity of crevices.

The strata that contain the lower flint opening lie between dense, smooth, unaltered cherty dolomite beds that are very distinctive in outcrops and are good key beds for geologic mapping. This opening is 35 to 39 feet below the top of the Cherty unit of the Galena dolomite.

The lower *Receptaculites* opening is 22 to 27 feet above the base of the Galena dolomite and is in cherty dolomite that is directly overlain by 14 feet of noncherty beds. Near Beetown, Wis., 20 miles northwest of the Couler Valley area, the largest continuous lead mine in the mining district was developed in this opening.

Because they were too deep, the openings in the Cherty unit have not been mined in the southwestern part of the Couler Valley area, where most of the lead mining was done. In the quarry at Eagle Point these openings are well developed along joints and are lined with large scalenohedral crystals of calcite as much as 4 inches long. A quarry in the SE¼SW¼SW¼ sec. 7, T. 89 N., R. 3 E., exposes a small cave at the upper flint opening, around which the rocks have been brecciated and limonite-stained. The interstices of the breccia have been filled and the opening has been lined with calcite. This also was observed at the lower flint opening in a small quarry in the center of the SW¼ sec. 12, T. 89 N., R. 2 E. No lead or zinc minerals were found at these localities.

The openings commonly are almost filled with partly disintegrated dolomite boulders, dolomite sand, and clay that is mainly a residue of the leached dolomite. The material on top of this crevice fill has been carried down the joint from the overlying rock formations, as is indicated by fragments of Maquoketa shale and chert from Silurian rocks. The galena, which was loosened from the crevice walls by the leaching of the dolomite, has fallen into this crevice-fill material as isolated chunks. Commonly, closely spaced crevices have openings that coalesce laterally and have been partly cleaned out by moving ground water, producing large caves. The Sunflower Cave in the SE¼SE¼ sec. 15, T. 89 N., R. 2 E., is 400 feet long and 25 feet wide. This cave was produced by a low-angle juncture of a minor crevice with the Sunflower crevice. The Timmens Cave in old Union Park in the NE¼SW¼ and the NW¼SE¼ sec. 10, T. 89 N., R. 2 E., is approximately 600 feet long and 10 to 15 feet wide. Other caves occur along the Levens range and Dubuques Cave crevice. All of these caves have been formed in the first opening zone, because, as the stratigraphically highest, it was exposed first to the action of ground water. The walls of several of these caves are covered with deposits of banded calcite ("onyx"). Large chunks of this material have been observed on a dump at the west end of Timmens Cave.

The openings are especially well-developed where a main crevice is intersected by minor joints. Such intersections are called "crossings" and were the loci of deposition for large deposits of lead. At these intersections the openings coalesce vertically in most places, producing "chimneys." Between crossings the lead ore along the crevice usually pinches out, so the lead deposits are discontinuous both vertically and horizontally; however, more than a mile of discontinuous deposits has been mined in some crevices.

The Fountain Hill diggings in the SE¼SW¼ sec. 1, T. 89 N., R. 2 E., and the shallow pits in the NW¼NE¼ sec. 12, T. 89 N., R. 2 E., were dug for galena concentrated in the residual clay by surface weathering of the bedrock bordering a lead crevice. This type of occurrence is called surface mineral or float lead by miners.

Zinc deposits.—Zinc sulfide has not been mined in the Couler Valley area; however, it has been reported as occurring with the galena in many of the crevices. For example, a prospect shaft on the Levens range in the SW¼SE¼ sec. 15, T. 89 N., R. 2 E., penetrated sphalerite-bearing ground (Calvin and Bain, 1900, p. 540).

The only zinc mineral recovered in this area was zinc carbonate, which has been observed on several of the old mine dumps in secs. 14 and 15, T. 89 N., R. 2 E. The Sunflower range was reported to have produced 300 tons of this mineral as of 1899, and a width of 10 to 12 feet of drybone-bearing ground was said to remain in the east face of the mine (Calvin and Bain, 1900, p. 544).

Because smithsonite is an alteration product of sphalerite, a crevice containing zinc carbonate probably has zinc sulfide in openings below the oxidation zone near the water table.

In the Wisconsin and Illinois portions of the district, zinc ore has been deposited as features in the rock called pitches and flats. Pitches are deposits in reverse faults that appear to be related to folding of the strata and probably are a result of lateral compression on the rocks. Subsequent solution and compaction of the beds opened these fractures, and the sphalerite and associated minerals were deposited in the open spaces and as minor replacements of the wall rock. Flats are deposits along bedding planes that were opened by differential flexing of the beds, or as replacement deposits along slightly opened bedding surfaces. Normally, pitches and flats are intimately associated in ore deposits. These two features are found in the Decorah formation and the lower part of the Cherty unit of the Galena dolomite. In the vicinity of Dubuque very few exploratory holes have been drilled into these deeper strata; therefore the presence of pitch-and-flat zinc deposits in the Couler Valley area has not been proved, although alteration effects that are indicative of this type of deposit have been observed.

CONCLUSIONS AND RECOMMENDATIONS

Lead sulfide deposits.—Results of this investigation indicate that commercial lead deposits probably remain in the Couler Valley area. First, much of the lead mining in the past has been concentrated in valleys where erosion has exposed the mineralized crevices. Shafts as deep as 100 feet were sunk into the uplands to find openings along the projected trend of crevices. If the openings were too deep beneath the uplands, the trend was projected to the next valley and the crevices were mined there, leaving unmined mineralized ground beneath the hills. Mineralized crevices have thus been followed in a nearly straight line for several miles. An example is the Levens range, which was mined at irregular intervals for a distance of 3 miles.

Second, in many places lower openings along a crevice have not been explored or mined. Very few of the mines in the Couler Valley area (except those of the Burton range in the NW¼ sec. 10, T. 89 N., R. 2 E.) have penetrated below the third opening, as shown by the absence of chert fragments on most of the old mine dumps. Mine dumps on the crevices in sec. 15, T. 89 N., R. 2 E., do not have fragments of the fossil *Receptaculites* on them, which indicates that only the first opening of these crevices was mined.

Third, at the time most of the mining was done in this area, pumps capable of lowering the water table appreciably were not available. Therefore, practically all of the lead deposits that were mined came from above the water table of that time, and deposits at lower levels remain unmined.

Mining of crevice lead deposits is relatively simple. Much of the lead ore occurs as large chunks of galena lying in unconsolidated dolomite sand and clay or solution-softened rock, which permits an easy separation of ore and gangue without milling. The smaller fragments of ore are recovered by means of a simple jig. Because the rock along crevices is soft, blasting should be kept to a minimum; and the drift widths should be kept as narrow as possible, in order to lessen the possibility of caving and to eliminate haulage of much barren rock.

Prospecting with a churn drill for crevice lead deposits presents a difficult threefold problem: (1) deposits are hard to find by vertical drill holes because the crevices are vertical and narrow; (2) if found by drilling, no accurate estimate of size, grade, or stratigraphic position can be made, owing to the fact that galena breaks easily and continues to enrich the drill cuttings at levels below the ore occurrence; and (3) deposits are difficult to locate because of their discontinuous nature. Where drilling has been used to find crevice deposits, the holes have been spaced 15 to 20 feet apart in a line across the trend of the crevice, with successive lines of holes spaced 100 to 200 feet along the crevice. Horizontal drilling in an opening zone within a mine has not been tried in the mining district; however, this type of prospecting could be used to advantage in exploring for ore in parallel crevices and in checking for mineralized crossings along a crevice and ahead of the mine face. Drilling for crevice deposits is considered impractical by some miners because of the mechanical difficulties of drilling in soft rock.

Shaft-sinking was profitably employed as a prospecting method by early miners. This method would now be very expensive, and sites for exploration of this type should be chosen very carefully. Shaft-sinking on the projected trend of a crevice would possibly be successful because of the constant direction of crevices. To intersect the projected crevice in a shaft would be fortuitous; however, a short cross-drift at an opening zone should locate the mineralized fracture.

In the past the reddish-brown limonite stain on the rocks in the vicinity of crevice-type deposits has been used as the most reliable guide to ore.

Much time and money could be saved in prospecting or mining crevice lead deposits if an elementary knowledge of the relative positions of openings and key horizons in the Galena dolomite were acquired by the prospector.

Zinc sulfide deposits.—If mining again becomes important in the vicinity of Dubuque, the pitch-and-flat zinc ore body zone in the Decorah and the lower part of the Galena formations will probably be explored. Ore deposits in this zone are related to synclinal and basinal structures, and an important result of investigations such as this one of the Couler Valley area is the location of this type of geologic feature. The northeast-trending synclinal area in the SW¼ sec. 7, T. 89 N., R. 3 E., is an example of such a structure. Folds do not guarantee the presence of zinc ore deposits, but the absence of such structures suggests the improbability of finding zinc-mineralized areas of any significance. The location of downwarped areas and their axial trends, therefore, is important in the selection of places to prospect.

Churn drilling is the standard method of exploring for pitch-and-flat deposits. Diamond drilling has been used but is more expensive than churn drilling, and sample recovery is unsatisfactory in the soft or broken rock common locally in this district. Nevertheless, diamond drilling provides much important information as to the type of deposit and association of minerals, which cannot be obtained from churn-drill cuttings.

Standard drilling procedure throughout the zinc-lead district for pitch-and-flat deposits was derived from experience and is described below. The average width of these deposits is about 100 feet. The deposits are oriented with their length parallel to the axes of the folds; therefore drill holes spaced 50 to 100 feet apart are located in a line normal to the axes of synclines. These lines of holes are repeated at intervals of several hundred feet along the axial trend of downwarped structures. Areas surrounding holes that penetrate zinc-mineralized ground are further explored by additional closely spaced holes. Where bedrock outcrops are sparse, a grid pattern of drilling has been employed to find downwarped bedrock areas. The holes are spaced 660 to 1,320 feet apart to coincide with the farm fence lines that are laid out according to the subdivisions of sections. Additional holes are drilled in the grid areas to verify structures and to get information near holes that have penetrated zinc-mineralized strata. In contrast with drilling for crevice deposits, the size and grade of pitch-and-flat zinc deposits can be determined from drilling data.

Rock alteration associated with zinc deposits is a significant guide to finding ore. The most readily observable alteration is carbonate-leaching and shalification of the argillaceous limestones of the Decorah formation, particularly the Guttenberg member, which alters from a dense limestone with shale partings to a residue of dark-brown carbonaceous shale (see Rock alteration). The Cherty unit of the Galena dolomite may also be leached and thinned, but to a much lesser degree than the Decorah formation.

Alteration of limestone to dolomite in the Decorah commonly was accompanied by zinc mineralization and extended peripherally out from zinc ore bodies. Thus exploratory holes encountering dolomitic Decorah strata suggest the possibility of nearby zinc ore.

Zinc carbonate deposits.—Zinc carbonate deposits occur in either crevice or pitch-and-flat zinc deposits in the oxidized zone above the water table. As zinc carbonate has little value on the present market, deposits of it can only be considered as reserve for future exploitation.

Iron sulfide deposits.—Iron sulfide that is associated with zinc ore has been—but is not now—recovered as a byproduct of zinc mining. In Wisconsin it has been a source of sulfur dioxide for sulfuric acid. No large deposits of iron sulfide are known in the Couler Valley area; however, the abundant oxide of iron associated with crevice lead and zinc deposits above the water table implies the presence of unoxidized iron sulfide below the water table.

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GEOLOGY AND ZINC-LEAD DEPOSITS IN THE COULER VALLEY AREA, DUBUQUE COUNTY, IOWA

By

C. Ervin Brown, Lorence G. Collins, and Percy Crosby

1955

MINERAL INVESTIGATIONS
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Iowa (Couler Valley area). Lead and zinc. cop. 2.

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