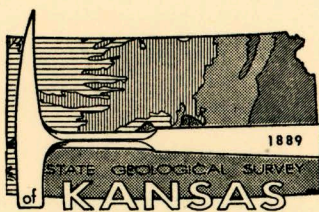

Short Papers on Research in 1969

Edited by Doris E. Zeller

STATE
GEOLOGICAL
SURVEY
OF
KANSAS

BULLETIN 199, PART 1



THE UNIVERSITY OF KANSAS
LAWRENCE, KANSAS - 1970

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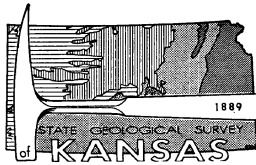
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BULLETIN 199, PART 1

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Short Papers on Research in 1969

This collection of papers continues the series begun in 1967 as a part of the *Reports of Studies* in the Bulletin. The papers present scientific and economic results of work by members of the State Geological Survey of Kansas and others during the calendar year 1969.

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PEI-LIN TIEN
TRUMAN C. WAUGH

Epsomite and Hexahydrate from an Underground Storage Area, Atchison, Kansas

ABSTRACT

Epsomite and hexahydrate occur on the walls, pillars, and ceilings of an underground storage area in the Plattsmouth Limestone Member (late Pennsylvanian). These minerals are confirmed by X-ray diffraction analysis. Pure epsomite is found in an area of low temperature (14-16°C) and high relative humidity (90-91 percent). Hexahydrate is found in an area of higher temperature (20-24°C) and lower relative humidity (38-40 percent). Both field and laboratory evidence indicates that hexahydrate is formed by dehydration of epsomite, which is not stable under laboratory conditions (temperature above 20°C, R.H. below 70 percent). To the authors' knowledge, this is the first reported occurrence of hexahydrate from Kansas.

White efflorescences were collected from several locations in Page Airways' underground storage area, about 1 mile south of the town of Atchison, Atchison County, Kansas. X-ray diffraction data indicate that these are either epsomite or hexahydrate, or a mixture of the two. Because the temperature and humidity of the sample locations in the storage area are not the same, the distribution and occurrence of the efflorescences may offer an opportunity to better understand and study the genesis of these two minerals.

Epsomite or epsom salt ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) is noted in a list of Kansas minerals (Mudge, 1881). However, this is the first reported occurrence of hexahydrate ($\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$) from Kansas.

The height of the storage area in the Plattsmouth Limestone Member of late Pennsylvanian age (Jewett, O'Connor, and Zeller, 1968) is 12 feet. Chert nodules are common in the limestone, which also contains minor amounts of dolomite (Hill, 1964). The efflorescences cover the walls, pillars, and ceilings of the galleries, and occur locally on the floor.

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E. E. Angino first brought the samples to the attention of the senior author for identification and suggested the study. William Jackson of Page Airways, Incorporated, kindly guided the authors to collecting localities in the mine and supplied the data on temperature and relative humidity for the different sections of the storage area.

In an area of no temperature and relative humidity control, the efflorescence is epsomite which occurs as fibers or whiskers (Fig. 1, *A*) and crusts (Fig. 1, *B*). Epsomite is especially concentrated (1) along the contacts between the clay partings and the limestone (Fig. 1, *C*); (2) along the contacts between the chert nodules and the limestone (Fig. 1, *D*); and (3) on the ceilings (Fig. 1, *E*).

In the area of controlled temperature and relative humidity the efflorescences are hexahydrate, or a mixture of epsomite and hexahydrate. Pure hexahydrate shows earthy or columnar structures (Fig. 1, *F*). The mixtures are all in powdered form.

Samples of hexahydrate were collected from the pillars of the storage area proper. Samples consisting of epsomite and hexahydrate were collected from the ceilings of the marginal area. Samples were capped tightly in glass jars, and the laboratory examinations were carried out within one week after collection.

In the controlled area the temperature ranges from 20 to 24°C, with a relative humidity range from 38 to 43 percent. In the uncontrolled area the temperature ranges from 14 to 16°C, with a relative humidity of 90 to 91 percent.

X-ray diffraction data (Table 1, 2) were obtained by packing the powdered samples in aluminum holders. Copper radiation was used with a Philips-Norelco X-ray diffractometer, a curved lithium-crystal focusing monochromator, and a gas-sealed proportional counter. The scanning speed was $0.5^\circ 2\theta$ per minute, and chart speed was 0.5 inch per minute. The 2θ values were obtained by measuring the center of the half-height of the diffraction peaks. Either the heights of $K\alpha$ peaks or the average heights of the $K\alpha_1$ and $K\alpha_2$ doublets were used for calculation of the relative intensities.

X-ray diffraction data for Kansas samples are compared with those for epsomite and hexahydrate available in the literature. The data for Kansas epsomite are close to those for

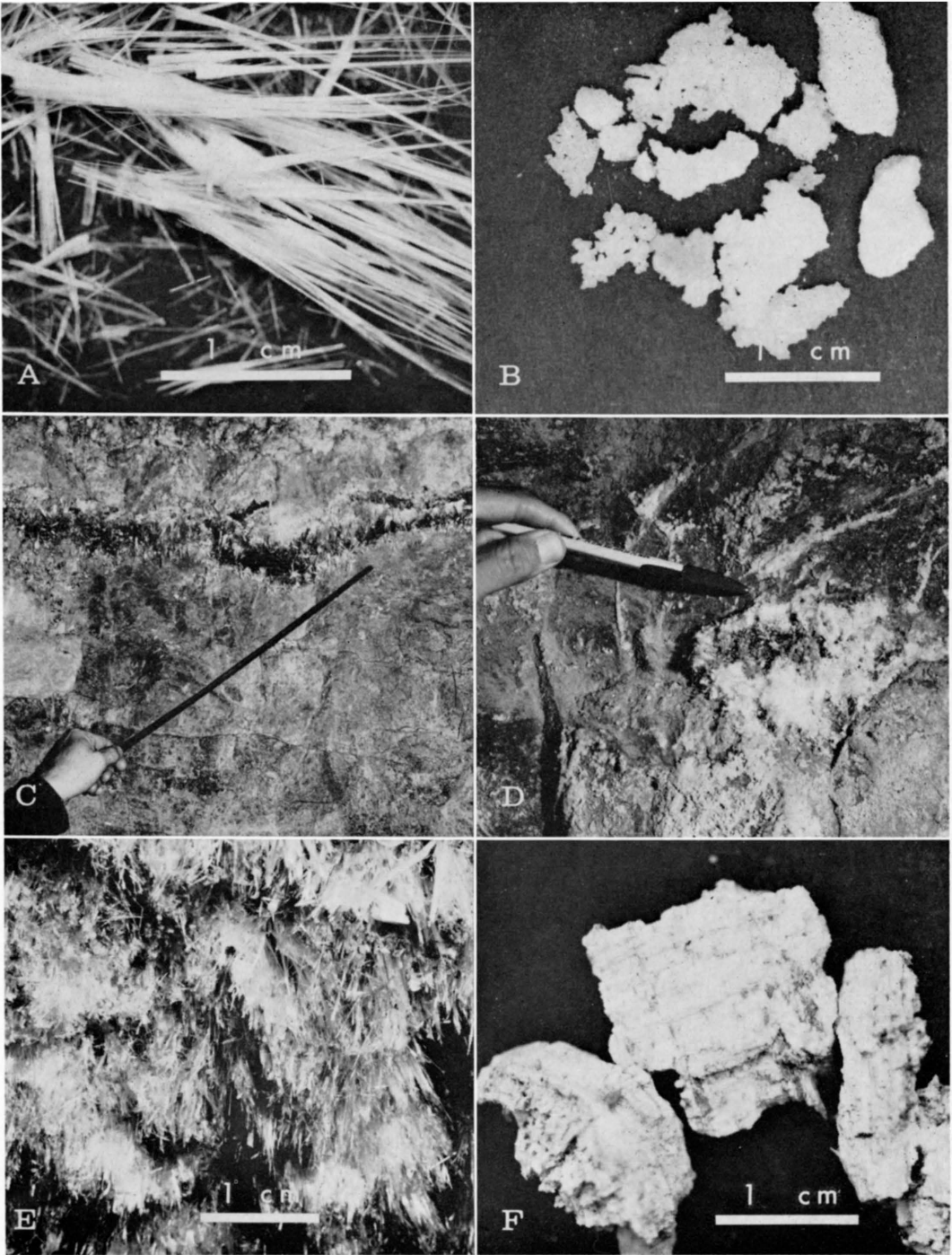


FIGURE 1.—Forms of epsomite: *A*, Fibrous; *B*, Crusted; *C*, Epsomite along contact of clay parting and limestone; *D*, Epsomite along contact of chert nodule and limestone; *E*, Epsomite on ceiling of gallery; and *F*, Aggregates of hexahydrate showing columnar structure.

TABLE 1.—X-ray powder data for epsomite.

1*		2+		1*		2+		1*		2+	
d(A)	I	d(A)	I	d(A)	I	d(A)	I	d(A)	I	d(A)	I
5.980	20	5.99	20	2.350	2	2.352	<1			1.679	<1
		5.95	6			2.258	6	1.664	<1	1.661	3
5.342	45	5.35	26	2.252	3	2.253	8	1.658	1	1.658	4
4.486	4	4.48	14	2.222	3	2.229	4			1.650	3
4.214	100	4.21	100	2.204	8	2.206	12	1.649	2	1.646	1
3.781	35	3.79	14	2.115	2	2.115	8	1.631	3	1.632	4
3.753	12	3.76	8	2.104	2	2.110	4	1.514	1		
3.453	7	3.453	16	2.039	3	2.040	2	1.498	2		
3.421	1	3.424	2	2.016	2	2.017	4	1.483	2		
3.302	4	3.304	4	1.966	1	1.964		1.472	2		
3.178	1	3.178	6	1.953	2	1.955		1.453	2		
2.997	10	3.000	14			1.900	2	1.443	<1		
2.987	10			1.893	7	1.894	2	1.407	<1		
2.977	5	2.977	14			1.882	2	1.402	<1		
2.891	15			1.877	2	1.877	2	1.392	<1		
2.878	50	2.880	20	1.860	4	1.861	2	1.386	<1		
2.807	6	2.812	2	1.828	1	1.826	<1	1.374	<1		
2.748	10	2.748	14	1.801	2	1.799	4	1.357	4		
2.674	20	2.677	25			1.795	2	1.338	2		
2.659	30	2.659	20	1.726	5	1.726	3	1.328	1		
2.488	1	2.493	2			1.712	2	1.313	3		
		2.482	<1	1.702	<1	1.710	2	1.175	1		
2.386	5	2.389	6	1.697	1	1.695	2				

* Kansas sample.

† Synthetic $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ (Swanson, Gilfrich, and Cook, 1957).

TABLE 2.—X-ray powder data for hexahydrate.

1*		2+		1*		2+		1*		2+	
d(A)	I	d(A)	I	d(A)	I	d(A)	I	d(A)	I	d(A)	I
6.038	3			2.898	35			2.021	5		
5.798	4			2.826	4			2.014	9	2.00	20
5.454	35	5.5	28	2.789	11	2.77	28	1.995	4		
5.102	31	5.1	24	2.769	15			1.978	3		
5.002	8			2.726	3			1.932	3		
4.879	25	4.9	24	2.682	13	2.67	24	1.879	9	1.87	24
4.549	5			2.596	3			1.862	6		
4.393	100	4.4	100	2.576	6	2.56	8	1.819	3		
4.155	9			2.522	13	2.50	16	1.800	4	1.80	4
4.036	38	4.04	32	2.469	3			1.783	4		
3.888	6			2.441	3			1.763	5	1.76	
3.602	16	3.61	20	2.338	4			1.731	3		
3.454	13	3.42	16	2.316	4			1.697	2	1.69	4
3.382	10			2.306	4			1.653	1		
3.290	3			2.295	6			1.6229	<1	1.62	4
3.192	14	3.20	12	2.280	11	2.28	24	1.5120	<1		
3.094	1			2.222	1			1.4998	<1	1.50	4
3.030	10			2.199	3	2.20	4	1.4681	<1	1.46	4
2.959	9			2.068	5			1.4540	<1		
2.936	27	2.92	60	2.051	1	2.05	8				

* Kansas sample.

† ASTM Data File, 1-0354.

synthetic $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (Swanson, Gilfrich, and Cook, 1957). The hexahydrate, on the other hand, yields more peaks on the diffractometer chart than those previously reported (ASTM, 1967; Tasch and Angino, 1968).

Epsomite is not stable; it partially dehydrates

to hexahydrate within 3 hours, and completely converts to hexahydrate within 36 hours in the laboratory (R.H. 60-70 percent; 23°C). No intermediate stage was detected by X-ray diffraction during the dehydration of epsomite (Fig. 2).

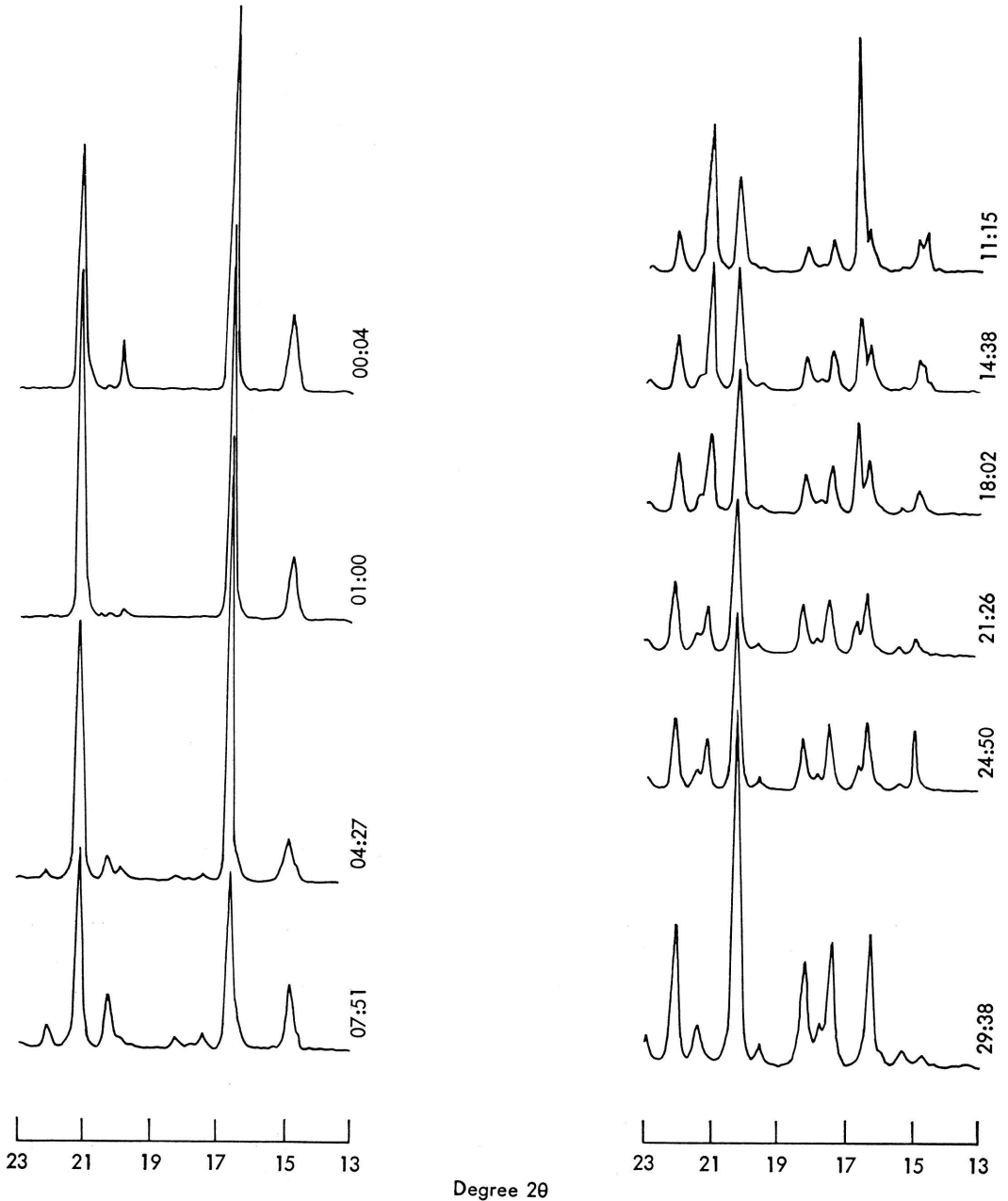


FIGURE 2.—X-ray diffraction pattern illustrating changes of epsomite in course of dehydration to hexahydrate. Scanning time for each pattern is 20 minutes. Time at beginning of patterns is expressed as hour and minute after sample was exposed in laboratory.

Curves in Figure 2 are representative of a continuously repeated X-ray diffractogram which arbitrarily was made in the scanning range between 13 and $23^\circ 2\theta$. The scanning speed was $0.5^\circ 2\theta$ per minute with a chart speed of 0.25 inch per minute.

Quantitative spectrographic analyses on the epsomite and hexahydrate indicate that Si, Ca, Fe, and Cu were present in trace amounts in both minerals studied. Na, Mn, and Ni were found only in the hexahydrate sample.

The basic elements necessary in the composition of epsomite and hexahydrate are magnesium and sulfur. Two samples of the Plattsmouth Limestone from Atchison County contained 1.31 and 3.17 percent MgO, 0.09 and 0.14 percent SO_3 , and 0.06 and 0.12 percent S respectively (Hill, 1964). The trace elements found in samples of epsomite and hexahydrate are also

found in the above two limestone samples. The overburden of the storage area consists mainly of shales which contain more sulfides (pyrite and/or marcasite) than the limestone. The sulfides in the shales may have been oxidized to sulfuric acid and subsequently carried downward by meteoric water. Through the interaction of this acidic solution with the limestone, calcium and magnesium sulfates have formed. Because magnesium sulfate is more soluble than calcium sulfate, it may be carried farther by the meteoric water along the capillaries, fissures, joints, and bedding planes. Under favorable conditions, magnesium sulfate is deposited as epsomite, which is unstable both in the area of controlled temperature and humidity and in the laboratory. Epsomite dehydrates rapidly and forms hexahydrate.

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MAYNARD P. BAULEKE
WILLIAM B. HLADIK

Expansion Characteristics of Calvert Volcanic Ash (Pliocene) in Kansas

ABSTRACT

Calvert volcanic ash (Pliocene) has been expanded, producing a low-density closed cellular structure similar to that produced in Pearlette volcanic ash (Pleistocene). Expanded bulk density is somewhat higher than that of the Pearlette ash.

It was previously reported (Carey, *et al.*, 1952, p. 38) that Calvert ash does not expand. The easily expanded Pearlette ash and the reportedly nonexpandable Calvert ash have similar physical and chemical characteristics (Table 1). The comparative properties would indicate that Calvert ash should expand. Ceramic slips containing Calvert ash require more water for fluidity, just as do slips containing Pearlette ash, indicating that approximately the same internal pore structure exists in the shards.

Using the same expansion procedure and equipment as used with Pearlette ash, a sample of Calvert ash (NNV-1A) was expanded to a structure similar to that produced in Pearlette ash. It required a higher flame temperature to produce cellular expansion. The temperature observation is strictly qualitative, based on the amount of gas input. Actual temperature mea-

surement of a flame with glowing insulative particles in suspension is difficult. Microscopic examination (Fig. 1) shows good expansion of many shards. However, many shards show only partial expansion, hence the reported bulk densities (Table 2) are higher than Pearlette ash. (Commercially expanded Pearlette ash has a bulk density of 6-7 pounds per cubic foot).

TABLE 2.—Comparison of vibration-compacted bulk densities of Calvert and Pearlette cellulated volcanic ash.

Particle size	Bulk density (lbs per cu ft)	
	Calvert ash	Pearlette ash
+24 mesh	6.6	4.9
-24 + 60 mesh	2.3	2.1
-60 mesh	8.3	6.0

I do not think the higher bulk density problem is unsolvable. A careful study of burner design, rate of feeding, and air classification should produce an expanded Calvert ash that is indistinguishable from an expanded Pearlette ash.

It is often asked if there is a health hazard accompanying the handling of expanded vol-

TABLE 1.—Comparative properties of Pliocene (Calvert, NNV-1A) and Pleistocene (Pearlette, JV-6) volcanic ash*.

	Chemical analysis		Particle-size analysis		Particle geometry		Index of refraction, ave.		
	NNV-1A	JV-6	NNV-1A	JV-6	Typical Pliocene ash	Typical Pleistocene ash	NNV-1A	JV-6	
SiO ₂	73.44%	73.32%	20 mesh	5.40%	0.02%	Shards flat and thin	Shards curved	1.501±.001	1.499±.002
								Range: 1.503-1.498	
Al ₂ O ₃	11.36	10.76	60 mesh	1.31	0.20				
Fe ₂ O ₃	2.01	1.66	150 mesh	3.52	2.51				
TiO ₂	0.39	1.36	200 mesh	17.48	20.40				
CaO	0.61	0.53	pan	72.27	76.87				
MgO	0.08	0.23							
K ₂ O	5.23	5.30							
Na ₂ O	2.33	2.27							
L.O.I.†	3.93	3.93							

* Data taken from Carey, J.S., *et al.*, 1952.

† L.O.I. = loss on ignition.

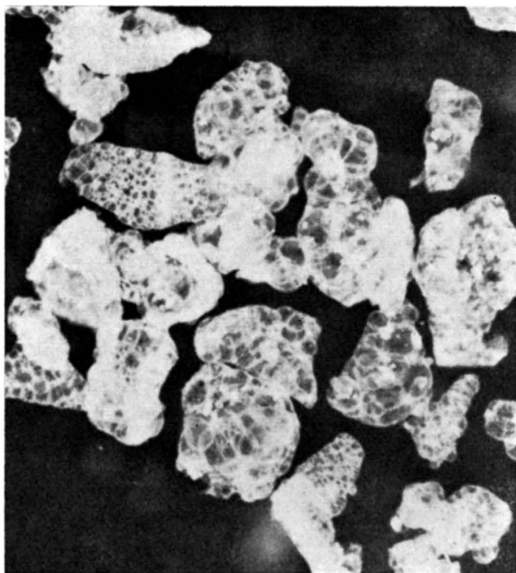


FIGURE 1.—Cellulated structure in expanded Calvert volcanic ash, $\times 35$. Picture made by direct projection of ash image onto enlarging paper.

canic ash because it has such a low density and easily floats in the air. A search of books on occupational diseases reveals no reference to volcanic ash as a hazardous material. The X-ray pattern of crushed expanded ash (Fig. 2) is that of a typical amorphous material and shows no crystalline quartz. It is crystalline quartz that causes silicosis. Small amounts of expanded ash floating in the air are quite irritating to most people; they will not remain exposed to it any longer than necessary without protective breathing masks. As far as we know, there is no danger of silicosis from the expanded volcanic ash. It is recommended that the usual normal,

established health requirements for handling dusty material be followed, as too much of any dust can cause temporary irritations.

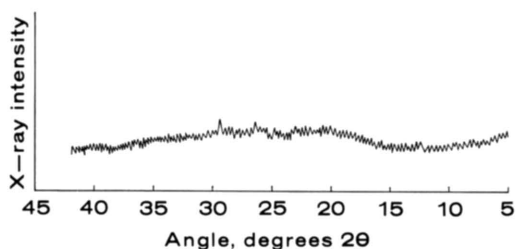


FIGURE 2.—X-ray diffraction pattern for crushed expanded volcanic ash. (Cu radiation, 100 counts/sec.)

The above remarks refer only to the volcanic ash after it has passed through the expansion process or to an ash deposit that is completely free of crystalline silica (sand). If the ash deposit contains small particles of sand, normal safeguards against silicosis must be taken in the mining operation and handling of the ash in the pre-expansion stages in the plant. Any sand present will drop out of the air stream immediately upon leaving the burner as the sand does not change its density and will be too heavy to be carried in the air stream used to move the expanded ash.

Even though there is strong geological evidence that there are at least two distinct ash falls in Kansas separated in geological time, many of the physical and chemical properties of the ashes are similar, suggesting that the source area for each was from the same general volcanic area. Lava chemistry must have been similar. The best expansion behavior seems to be associated with the "fresh" ash, i.e., ash that has not started to alter to montmorillonitic clay minerals.

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ALLISON L. HORNBAKER
WILLIAM B. HLADIK

Toxicant-Carrier Granules from Kansas Bentonite With a Volcanic Ash Additive

ABSTRACT

Increased sorptivity and lower bulk density of toxicant-carrier granules result when volcanic ash (both raw and processed) is used as an additive to Phillips County bentonite. Preparation of the bentonite includes oven drying and fine grinding. Granules made from 100 percent bentonite have sorptivity (kerosene) of 16 percent and a bulk density of 52 pounds per cubic foot. Best results were obtained using 60 percent by volume processed ash as an additive, increasing sorptivity to 29.44 percent and lowering bulk density to 31.8 pounds per cubic foot.

Toxicant-carrier granules made from clay are used in greater amounts each year, especially in the corn belt. Granules made exclusively from Kansas bentonite have a relatively low sorptive capacity but have other toxicant-granule interaction characteristics that appear to produce more effective field results when compared with other commercial carrier granules. The primary purpose of this study was to increase the sorptive capacity and lower the bulk density of the bentonite granules and still retain the desirable characteristics that produce the more effective results.

Because there is, in our opinion, no suitable standardized test that gives reproducible results to determine free-flow sorptive capacity of clay carrier granules, we devised the following test procedure which, when followed carefully, will give a true indication of sorptive capacity for free-flow granules.

The apparatuses used in running this test were a warming oven, a dessicator, a balance (accurate to 0.1 g), a 10-ml burette (0.05 ml divisions), 12 250-ml glass beakers, and a stop watch. The sorptive capacity of a clay granule, calcined or oven-dried raw, is determined by adding kerosene (specific gravity 0.80 @ 23°C) to a 10-g sample of the granules contained in a 250-ml glass beaker until at the end of a 3-minute test period, the granules are saturated but still free-flowing. At no time is a spatula

or stirring rod used to mix the granules. Time, initial and end rate of introduction of kerosene, thorough mixing, and determination of end-point are critical to obtain consistent results; therefore the procedure must be followed carefully. Experience will enable the tester to obtain consistent results. When possible, tests on granules with known sorptive capacity should be run before running tests on unknown material. At least four preliminary tests should be run on the sample to be tested in order to determine what the sample should look like at the three-minute end-point.

Procedure for conducting the test is as follows:

1. Dry sample at $105 \pm 5^\circ\text{C}$ for 3 hours. Mix and cool in a dessicator.
2. Weigh 10 g of dried sample accurately on a triple-beam balance and transfer to 250-ml glass beaker.
3. Read kerosene level on burette to nearest 0.01 ml by estimation and record.
4. Timing:
 - a. First minute:

Start stop watch. Introduce one-half to three-fourths the required amount¹ of kerosene to saturate granules during the first minute. Granules must be in continuous rapid motion while kerosene is being added. Mix thoroughly with a quick rotary wrist motion of the hand-held beaker. Caution: Do not swirl granules out of beaker.

- b. Second minute:

Add kerosene in rapid drop-by-drop amounts, mixing with quick rotary motion until granules begin to appear wet but are still free-flowing. Care should be taken not to oversaturate.

c. Third minute:

Add kerosene slowly drop-by-drop, mixing thoroughly until granules tend to adhere to one another. Close visual inspection away from burette is necessary. The end-point is reached at 3 minutes after start of test when the free-flow is retarded by a tendency for the granules to agglomerate, and when a thin film of kerosene adheres to the edge of the beaker. The end-point is critical and should be the same each time a test is run for a particular class of material to assure uniform results. The end-point is exceeded when granules appear wet, are not free-flowing, and adhere to beaker and to each other to form $\frac{1}{8}$ -inch or larger masses.

5. Read the burette and record.

6. Run three samples and average amount of kerosene absorbed.

Sorptive capacity is calculated as follows: average ml of absorbed kerosene \times specific gravity (0.8) \times 10. The procedure for cleaning the equipment is:

1. Rinse with NaOH solution.
2. Rinse with distilled water.

3. Rinse with isopropyl alcohol.

An alternate method is to flush equipment with acetone.

Phillips County bentonite calcined at 1200° F produces a granule with a 16-percent maximum sorptive capacity for free-flow and bulk density of 52 pounds per cubic foot. Because of the close association and genetic relationship between bentonite and volcanic ash, volcanic ash was selected as an additive to increase the sorptive capacity, at the same time retaining the desirable properties of the 100-percent bentonite granules already tested. Additional tests must be conducted in the laboratory and in the field to determine the reactive effect on toxicants and performance in the field.

Two types of Long Island bentonite samples were prepared for the test. One sample was slaked in water, thoroughly mixed and spray-dried. The second was oven-dried and ground to -40 mesh. Both samples were then mixed with various proportions by volume of raw Calvert ash, bloated Calvert ash, and crushed, bloated Calvert ash. Water was added in measured amounts to the dry ash-bentonite mixes and blended with a wire beater to the point where the bentonite-ash mixture agglomerated into distinct granules or pellets. The material was then fired at 1200° F, crushed, and screened

TABLE 1.—Test results on bentonite granules with volcanic ash additives.

Sample no.	Mixture and proportions								Sorptive capacity	Bulk density (approx.)
	By volume, %					By weight, g				
	Bentonite		Calvert ash			Bentonite	Calvert ash	H ₂ O, cc†		
SD*	G*	R*	B*	CB*						
1	80	....	....	20	....	214.0	5.3	110	20.64	41.3
2	60	....	....	40	....	160.5	10.6	90	21.60	37.6
3	40	....	....	60	....	107.0	15.9	90	28.72	29.7
4	80	....	20	....	....	214.0	42.0	100	23.2	39.7
5	60	....	40	....	....	160.5	84.0	90	23.84	37.1
6	40	....	60	....	....	107.0	120.0	80	24.32	36.4
7	80	....	....	....	20	214.0	10.5	100	19.04	42.3
8	60	....	....	....	40	160.5	21.0	100	22.56	37.7
9	40	....	....	....	60	107.0	31.5	85	25.92	34.1
10	40	....	60	....	....	107.0	126.0	100	24.0	36.3
11	....	80	....	20	....	208.0	5.3	110	19.92	41.6
12	....	60	....	40	....	156.0	10.6	90	22.56	37.4
13	....	40	....	60	....	104.0	15.8	70	28.96	30.7
14	....	80	20	....	....	208.0	42.0	100	19.20	44.3
15	....	60	40	....	....	156.0	84.0	90	26.36	37.4
16	....	40	60	....	....	104.0	126.0	80	27.12	35.2
17	....	80	....	....	20	208.0	10.5	100	21.20	43.5
18	....	60	....	....	40	156.0	21.0	90	24.24	37.6
19	....	40	....	....	60	104.0	31.5	80	29.44	31.8
20	....	40	60	....	....	104.0	126.0	100	24.96	35.9

* SD=spray dried; G=ground, oven-dried (-40 mesh); R=raw; B=bloated; CB=crushed & bloated.
 † H₂O added to bentonite-ash mixture (in g).

to obtain a 16-40-mesh-sized granule. Sorptive capacity and bulk density was determined for each sample (Table 1).

In summary, sorptive capacity of clay granules was increased from 16 percent for composite samples of calcined bentonite to 29.44 percent granules made from 40-percent bentonite and 60 percent by volume of crushed, bloated volcanic ash, pelletized and calcined. Bulk density decreased from 52 pounds per cubic foot to

31.8 pounds per cubic foot. A blend with 60 percent raw ash and 40 percent bentonite by volume produced granules with 27.12 percent sorptivity and bulk density of 35.2 pounds per cubic foot.

Raw ash as an additive to bentonite for the purpose of increasing sorptivity and decreasing bulk density produces slightly less benefit than processed ash; therefore, it should be more economical for the results achieved.

MAYNARD P. BAULEKE
JOHN M. HUH

Ceramic Belt Buckles—A New Consumer Item?

ABSTRACT

Ceramic belt buckles were designed, manufactured, and tested. Any high-strength vitrified ceramic body having a modulus-of-rupture greater than 20,000 psi may be used in their production. Field testing demonstrated the feasibility of the use of ceramic belt buckles as a fashion accessory for men or women.

For centuries ceramics have been brittle and weak, but modern developments in the chemistry of ceramic bodies are changing these characteristics. True ceramics are still brittle, but they no longer need be weak. Under compression, ceramics are much stronger than metals. Many of the new high-strength alumina porcelains have a tensile strength equal to that of the metals.

The suggestion that a colorful ceramic belt buckle might add a spice of color to a wardrobe resulted in the development and testing of such a buckle. It is hoped that this experimentation may stimulate others to design and produce ceramic belt buckles, or other fashion accessories.

A reasonably high-strength (20,000 psi modulus-of-rupture) body was selected to test the feasibility of this idea; however, no study was made of the ceramic body that would be best suited for a belt buckle. The composition (Table 1) was modified for slip-casting by substituting Kentucky old mine #4 ball clay kaolin. The composition was ball-milled overnight for 14 hours.

A large and a small buckle were modeled in clay and three-piece plaster-of-paris molds (Fig. 1) made from them for slip-casting. The best forming method would be dry pressing in a steel die, but the cost of the die was too prohibitive to use for only a few buckles. The hook was cast as an integral part of the buckle. This is an old design used for centuries in casting metal buckles.

All buckles were solid-cast. Because entrapped air bubbles will cause a zone of weakness in the buckle, a hand vibrator was held

TABLE 1.—Ceramic body and slip composition for buckle.

Raw materials*, body composition	Weight percent
Alumina, Reynolds RC-2GF	33.3
Nepheline syenite, A-400	33.4
Kentucky old mine #4 ball clay	33.3
	100.0
<i>Slip</i>	
Water	30.0
Calgon (sodium hexametaphosphate)	0.2

*Modified from Floyd, 1966, p. 60.

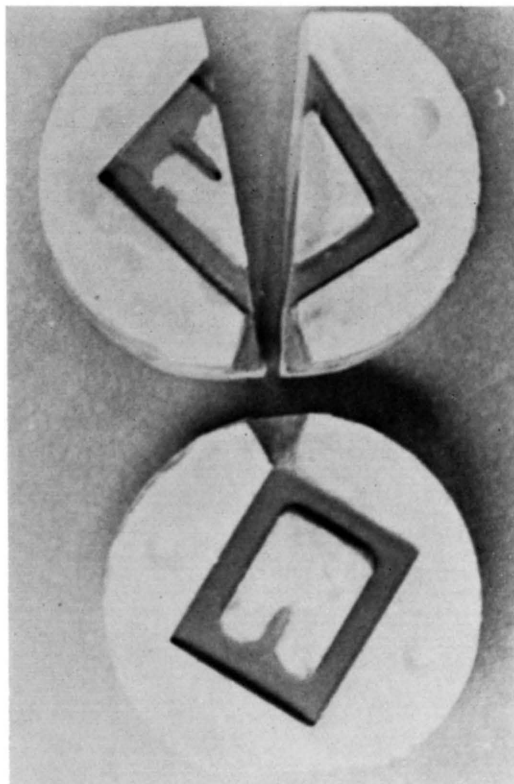


FIGURE 1.—Three-piece plaster-of-paris mold for slip-casting large belt buckles.

gently against the mold to force to the surface any bubbles present.

After the cast was rigid, it was removed from the mold, dried, and flash removed. Smoothed buckles were bisqued to 1500°F, then glazed by dipping and fired to cone 3 (2100°F) to mature both the body and the glaze. During firing the buckle was hung on a small refractory rod hung between two refractory supports. A small area of glaze was removed from the inside surface of the buckle to prevent the glaze from sticking to the refractory rod. This unglazed part of the buckle is covered by the belt.

It is very important to select a noncrazing glaze such as shown in Table 2. The glazed surface must be in compression. A tension surface (crazed glaze) can reduce the modulus-of-rupture by as much as 80 percent, almost ensuring failure of the buckle on the wearer.

TABLE 2.—Composition of cone 3 glaze.

Composition	Weight	percent
G-24 frit*	70	
Pioneer air-float kaolin	15	
Nyralc	5	
Zircopax	5	
Flint	5	
		100
Hercules gum	0.75	
Water	65.0	

*Empirical formula G-24 frit:
 0.21 Na₂O 0.12 Al₂O₃ 2.60 SiO₂
 0.29 CaO 0.66 B₂O₃ 0.07 ZrO₂
 0.50 PbO

Single firing of the body and glaze was tried, but difficulties in applying a uniform glaze coating developed, and often the green body would absorb excess moisture and deteriorate. Only the two-stage firing method produced satisfactory buckles.

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Floyd, J. R., Sterne, J. H., III, and Deutscher, J. S., 1966, Test technique makes a difference: *Ceramic Age*, v. 82, no. 4, p. 60.

A scheme for the major steps in production of belt buckles is summarized in Figure 2.

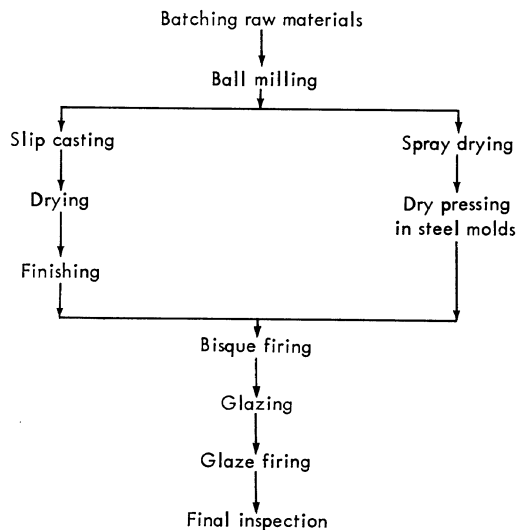


FIGURE 2.—Processing diagram for production of ceramic belt buckles.

Many variations can be developed. Any ceramic composition that is vitreous, has a modulus-of-rupture greater than 20,000 psi, and has a matching compressive glaze would be satisfactory. A semi-vitreous body, even with a compressive glaze, rarely develops a 20,000 psi modulus-of-rupture and is not a satisfactory type of body.

Thirty ceramic belt buckles were slip-cast, fabricated as described, and were then distributed to a number of persons for testing. Only one buckle is known to have failed in two years of wear. This failure was due to an air bubble that was not removed at the time of casting of the buckle.

MAURICE MORENCY, *Department of Geology*
 PIERRE L. EMOND, *Department of Physics*
 PETER H. VON BITTER, *Department of Geology* } *The University of Kansas*

Dating Conodonts Using Electron Spin Resonance: A Possible Technique

ABSTRACT

Electron spin resonance is a means of detecting, with microwaves, the presence of electrons trapped in the structure of crystalline material. Prior to being trapped, the electrons are released from their parent atoms by radiation from radioisotopes present in the conodonts and the host rock.

The feasibility of using electron spin resonance as a dating technique was tested on conodonts (fossil toothlike structures) from the Hols Summit Formation (upper Devonian), Missouri, the Bushberg Formation (upper Devonian to lower Mississippian), Missouri, and the Heebner Shale Member of the Oread Limestone (upper Pennsylvanian). All of the conodonts yielded an electron spin resonance spectrum arising principally from trapped electrons. It was found that this spectrum would be suitable for the age determination calculations described herein.

Interest in the use of electron spin resonance as a dating technique arises from two principal considerations: The electron spin resonance signal produced by phosphate minerals is relatively simple; it is proportional to the total radiation received. The results presented are only preliminary. A more detailed investigation is under way using a series of samples that range in age from lower to upper Pennsylvanian.

Electron spin resonance¹ refers to the magnetic resonance of a permanent dipole moment. Pictorially, an electron with moment μ , when placed in a constant magnetic field \mathbf{H}_0 precesses about the direction of \mathbf{H}_0 at a constant angle θ with a natural frequency given by:

$$\omega = \gamma \mathbf{H}_0 \text{ (Larmor precession),}$$

where γ is a constant.

If we apply microwave radiation, which is a small rotating magnetic field 'h' in a direction

perpendicular to \mathbf{H}_0 and having the same frequency as that of the precessing electron, θ will increase as the system absorbs power from the incident microwaves. Under these conditions the system is said to be "on resonance." Experimentally, we fix the frequency of the incident microwaves and vary \mathbf{H}_0 such that as we go through resonance the power absorbed by the sample is recorded by observing the variation of the power level of the microwaves. As we have assumed a paramagnetic system (one in which the electrons do not interact), any measure of the power absorbed (*e.g.*, peak height, width at half-power points) will be a relative measure of the number of trapped electrons in the sample. Background radiation produces free electrons which wander through the crystalline structure and are eventually trapped in defects called electron traps. Traps are various types of crystalline imperfections introduced during the crystallization process. They are vacant lattice points, impurity atoms, interstitial atoms, and the like. Alpha and beta radiation can also cause defects, but according to Zeller, Levy, and Mattern (1967) the formation of additional defects will be negligible if the total dose is low.

The procedure employed in dating the conodonts consists of first determining the electron spin resonance signal induced by the natural background radiation and then subjecting the sample to small additional doses of artificial gamma radiation in order to establish the dependence of signal growth on radiation dose. If the signal growth is linear, we can, by assuming a constant natural dose rate, make a linear extrapolation to determine the total natural radiation dose received by the sample (Fig. 1).

The background radiation, and hence the dose rate, is measured with a solid-state detector.

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We wish to express our gratitude to E. J. Zeller and A. J. Rowell, of the University of Kansas, for their interesting and stimulating discussions and the State Geological Survey of Kansas for the use of their facilities. We gratefully acknowledge the financial assistance from the U.S. Atomic Energy Commission under contract number AT(11-1)1057-7.

¹A rough macroscopic analogy might be that of a spinning top precessing about the direction of a gravitational field.

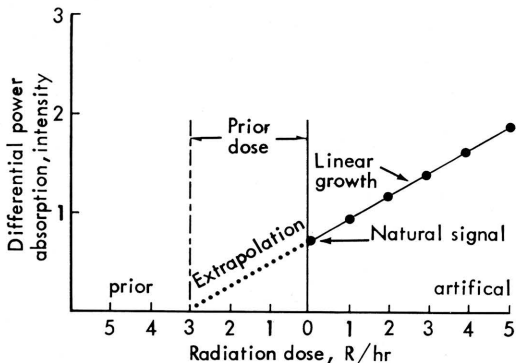


FIGURE 1.—Hypothetical age determination diagram (after Zeller, Levy, and Mattern, 1967).

Thus:

$$\frac{\text{Total natural dose (Rads)}}{\text{Dose rate (Rads/year)}} = \text{Age (years)}$$

The composition of conodonts places them in the dahllite-francolite isomorphous series (Deer, Howie, and Zussman, 1962). A prior investigation of minerals suitable for electron spin resonance dating (Zeller, 1968) yielded an age for an apatite sample whose composition approximated that of the aforementioned series. Since conodonts show essentially the same x-ray diffraction pattern as members of the dahllite-francolite series (Lindström, 1964), similar results to those obtained by Zeller could be expected.

The initial work was done on conodonts from the Hols Summit Formation (sandstone) of upper Devonian age, and a subsequent study

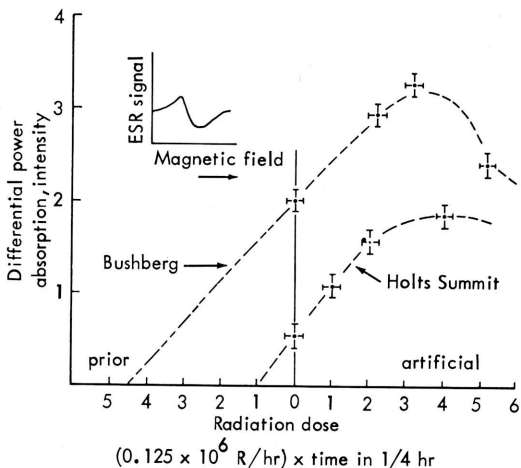


FIGURE 2.—Absorption peaks for the Hols Summit and Bushberg formations as a function of ⁶⁰Co gamma-ray dose. The signal has been extrapolated to determine the prior doses. Insert shows typical differential power absorption signal obtained for the Hols Summit and Bushberg formations.

on conodonts of the Bushberg Formation (sandstone) (Fig. 2).

The natural signal intensity was measured and plotted on the vertical axis at dose = 0. The sample was then subjected to successive doses of gamma radiation to establish the signal growth-rate. The signal response to radiation is linear until saturation of the traps is achieved (Fig 2). An interesting feature of the results obtained from the Bushberg sample is the marked decrease in signal intensity once initial saturation has been attained. Only unpaired electrons will contribute to the electron spin resonance signal. Since pairing of electrons will be more likely to occur once trap saturation is achieved (Vaz and Zeller, 1966), increased pairing will thus tend to diminish the signal intensity.

Conodonts from the Heebner Shale Member (Oread Limestone) were studied primarily because of the presence of high background radioactivity associated with black shales. Because of the presence of high amounts of uranium and thorium in their environment, the radiation damage, caused mainly by alpha particles, is detectable. This is reflected in the electron spin resonance signal emitted by the conodonts from the Heebner shale. The differential power absorption signal obtained from the Heebner conodonts (Fig. 3) shows several peaks occurring

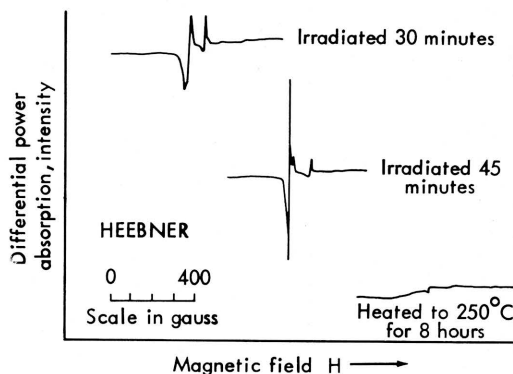


FIGURE 3.—Electron spin resonance absorption curves for the conodonts of the Heebner after irradiation in ⁶⁰Co gamma-ray source and heat treatment.

at different field strengths. The Hols Summit and Bushberg conodonts yielded broad single absorption peaks. These characteristics reflect the nature and distribution of types of traps within the samples. Thermal annealing experiments quantitatively support this explanation.

Conclusions

From the results presented above we can say:

- 1) Conodonts yield measurable electron spin resonance signals suitable for use in the age determination technique described above.
 - 2) From irradiation and thermal annealing experiments we know that the signals obtained arise from trapped electrons.
 - 3) The signal response to radiation is linear until trap saturation is achieved.
- One must keep in mind that after the conodonts are deposited in a particular environment, heat, pressure, and other geological processes can alter both trap population and number of traps.

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- , Levy, P. W., and Mattern, P. L., 1967, Geologic dating by electron spin resonance: *Radioactive Dating and Methods of Low-Level Counting*: Proceedings of symposium, International Atomic Energy Agency in Cooperation with Joint Commission on Applied Radioactivity (ICSU), Monaco, March 2-10, 1967, International Atomic Energy Agency, Vienna, p. 531-540.
- For additional information relating to this subject see:
- Levy, P. W., 1968, chap. 2.2, A brief survey of radiation effects applicable to geology problems: *Thermoluminescence of Geological Materials*, McDougall, D.J., ed.: Academic Press, London, p. 25-38.
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Research Notes

IMPROVED TECHNIQUE FOR PRODUCTION OF BLACK-AND-WHITE COPIES FROM COLOR TRANSPARENCIES

The advantages of using color film for taking pictures during field trips are apparent to the worker who gives papers or uses slides in oral reports. Black-and-white prints are usually included in field reports or publications because the cost of color printing is too prohibitive. Specific details, which are seen easily in color slides, however, do not show to the best advantage on the black-and-white print. For example, a yellow iron stain may not be differentiated from a background of light-brown limestone, or a green shale may not be distinguishable from a gray shale.

The medium-sized laboratory with a minimum of photographic equipment usually is not able to process color prints, even for limited use. Two alternatives are evident: both black-and-white and color pictures can be taken at the same time, or color transparencies can be taken and black-and-white prints made from them. The disadvantage of taking duplicate black-and-white pictures and color transparencies is in the bulkiness and duplication of photographic equipment. Two cameras must be used, or perhaps two interchangeable backs for one camera—one containing color film, the other, black-and-white film. Two different ASA film speeds for the two types of film might cause confusion and, consequently, more photographic failures, as not all research personnel are highly trained photographers.

Black-and-white prints from color transparencies are not difficult to make. Eastman Kodak¹ (1968²) recommends that slides be copied on Super XX Pan film (Estar thick base). The exposure is made, the film is developed in Kodak HC-110 developer, washed, and dried. Prints are then made from this black-and-white negative and the negative filed for future use. The suggested method gives good results but requires much time. Unless many slides are copied at one session, the time spent per slide is great. The method outlined below, however, yields copies of good quality, with a minimum of time per print.

Equipment used for the procedure described is a 4 x 5-inch condenser-enlarger equipped with

an f-5.6 150-mm focal-length lens, a Polaroid No. 545 Land film holder used in place of an enlarging easel, and the sensitized material is the Polaroid 4 x 5-inch Land film packet type 55 P/N.

1. The slide to be copied is placed in the negative-carrier of the enlarger and projected onto a white card in the film plane of the film holder. Because of the shape of the film holder, a heavy block, approximately 2 inches thick, is placed beneath it to support it in a level position. The block is also used to preset the position of the film holder so it may be relocated with respect to the projected image of the color slide (Fig. 1). The film holder is placed on

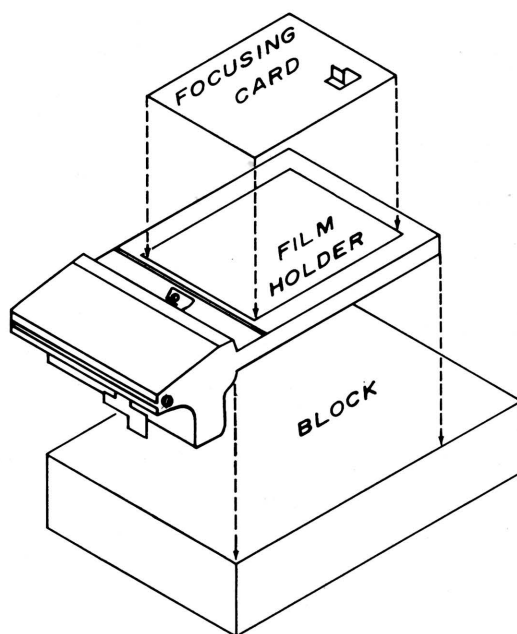


FIGURE 1.—Diagram showing exploded view of copying assembly.

the block so that the bottom edge of the film holder is even with the bottom edge of the block, and the "hump" on the back of the film holder is against the edge of the block.

2. In total darkness, the color slide is focused on the white card in the film plane. The block with the film holder on top is moved on the baseboard of

¹Mention of companies or products is not to be considered an endorsement.

²Eastman Kodak Company, 1968, "Copying," Kodak Publication No. M-1, 7th ed., Eastman Kodak Co., Rochester, N.Y., 44 p.

the enlarger with the film holder in register at all times. Care must be taken that the block does not slide on the baseboard during the following operations.

3. When the color slide is focused and cropped as desired, the film holder is removed and the white card laid aside. The film packet is placed in the film holder. In total darkness the protective cover of the film packet is withdrawn to a firm stop. The film holder is brought to register on the support block as before. This may be done by feel.
4. A trial exposure of 1 second at f-11 or f-22 is made. This is a mean exposure time only; due to variations in equipment, it should not be considered exact.
5. After the exposure is made, the protective cover is reinserted in the film holder. Processing may be done in

room light. The film packet is processed as described in the book that accompanies the film holder.

The result of this short process is excellent. It not only produces a well balanced black-and-white photograph, but also produces a negative of equally good quality. Two simple steps furnish a permanent negative. The lack of grain in the negative is favorable for large prints. Cropping the slides may be done at the time of exposure or when prints are made from the negative. Processing time from exposure to first print is 20 seconds. The range of gray tones in the black-and-white copy is slightly compressed as compared with that of the subject and the contrast of prints from the negative may be changed by choice of paper grade or printing filter.

Truman C. Waugh
Geochemistry Section
Pei-lin Tien
Geologic Research Section

ABSTRACTS

The following is a list of abstracts and titles of papers by Survey personnel presented orally and/or printed in publications other than those of the State Geological Survey of Kansas during the calendar year 1969. [Abstracts are reproduced exactly as printed in source or from copy supplied to editor.]

Angino, Ernest E., Galle, O. Karmie, and Waugh, Truman C.

FE, MN, NI, CO, SR, LI, ZN, AND SiO₂ IN STREAMS OF THE LOWER KANSAS RIVER BASIN

An attempt is made to ascertain the background levels and to measure seasonal variations of selected trace and minor elements in the major streams of the Lower Kansas River Basin. Knowledge of the trace element chemistry of river waters is becoming increasingly more important as the rate of use of stream waters increases. Excepting the case of strontium, no strong relation between trace element concentration and geology lithology was noted. To ascertain properly trace element background levels in streams, long-term sampling covering at least one seasonal cycle is essential. Variations in drainage basin geology have only a minor controlling influence on the trace element geochemistry of the wastes [*sic*] studied.

Water Resources Res., v. 5, no. 3, 1969, p. 698.

Attaway, David H.

STEROLS IN MARINE SPERMATOPHYTES AND RECENT MARINE SEDIMENTS

Public presentation, Marine Science Institute, The University of Texas, Port Aransas, Texas, December 18, 1969.

—; and **Parker, Patrick L.**, The University of Texas Marine Science Institute, Port Aransas, Texas

STEROLS IN RECENT MARINE SEDIMENTS

The variety of sterols in nature and the fact that certain ones are characteristic of certain types of organisms suggest that they may be useful organic geochemical indicators of environments.

A sterol fraction has been isolated from a core from Baffin Bay, Texas. The section of core used was approximately 2000 years old. The presence of cholesterol, γ -sitosterol, stigmasterol and β -sitosterol has been indicated by gas-chromatographic data and mass spectrometric data. The fraction of sterols was characterized by thin-layer chromatography and infra-red spectroscopy. The sterol fraction was isolated by column chromatography of the non-saponifiables obtained from the lipids of the core.

A similar fraction has been isolated from a sediment from San Pedro Basin, California.

The possible use of sterols as an indicator of the relative contribution of plants versus animals to sedimentary organic matter will be discussed.

Geol. Soc. America, Programs for 1969, Pt. 7, p. 4.

Berberick, James A., and Miller, Fred E.

A MODEL FOR REGIONAL MINERAL RESOURCE OUTPUT VS. PRICE DISCRIMINATION ANALYSIS

Public presentation, Fall meeting, Soc. Mining Eng. Am. Inst. Metall. Eng., Salt Lake City, Utah, September 17-19, 1969.

Conley, Curtis D.

STRATIGRAPHY AND LITHOFACIES OF LOWER PALEOCENE ROCKS, SIRTE BASIN, LIBYA

Late Cretaceous and Paleocene transgression in the Sirte basin resulted in deposition of basal sandstone followed by alternating shales and carbonate

rocks. The lower Paleocene is entirely shale in the central part of the basin. To the south and west, the lower Paleocene comprises three units, (1) lower shale, equivalent to the Upper Tar Marl and Dor el Gani Marl on outcrop, (2) middle limestone, equivalent to the Had Limestone and Scedida Dolomite on outcrop, and (3) upper shale, equivalent to the Bu Ras Marl and Dor el Msid Claystone on outcrop. The lower shale locally changes facies abruptly to coral—algal reef limestone on old structural highs. It becomes calcareous and sandy near the southern shoreline. The upper shale is increasingly calcareous and dolomitic southward.

The middle limestone was deposited on a broad, shallow shelf surrounding the open-sea basin where shale was accumulating. Calcarenes were deposited in turbulent water on old highs and along the southern shoreline, while calcilutite was deposited in quieter water in adjacent lows. Locally, coral—algal reefs flourished. Near the southern shoreline calcarenites were dolomitized, while along the shoreline intertidal and supratidal dolomites accumulated. On outcrop the facies change from Had Limestone on the north to Scedida Dolomite near the southern shoreline is analogous to the subsurface change from offshore limestone to nearshore dolomite.

The three lower Paleocene units exhibit continuous southward onlap in the subsurface as well as on outcrop. Thus, early Paleocene transgression on the southern and southwestern margin of the Sirte basin was continuous and persisted into the late Paleocene. Changes from widespread deposition of shale to shallow-shelf limestone and return to shale may be explained in several ways: (1) major changes occurred in the supply of fine terrigenous clastics to the basin from the north, (2) temporary reactivation of old highs or faults altered bathymetry sufficiently to initiate flourishing reef and bank growth and also to prevent currents from spreading fine clastics widely, and (3) subsidence was temporarily more rapid in the basin center allowing trapping of greater volumes of fine clastics. This would have cleared the water in marginal areas and promoted limestone deposition.

Symposium on the Geology of Libya, April 14-18, 1969, Proceed., Univ. Libya, in press.

Davis, John C.; and Preston, Floyd W., Department of Chemical and Petroleum Engineering, University of Kansas, Lawrence, Kansas

OPTICAL PROCESSING—AN ATTEMPT TO AVOID THE COMPUTER

The digital computer is an undeniable asset in the examination of many classes of geologic problems. Unfortunately, it is ill-suited for handling pictorial information, which constitutes a large percentage of geologic data. For certain types of problems, the inherent physical properties of optical lenses can be used to perform analyses that are impractical using a digital approach. For example, in a current study of pore structure in reservoir rocks, the pore pattern of an area 24 x 24 mm on a thin section was digitized, yielding over one million data points. Spectral analysis was used to determine the relative contributions of spatial frequencies to the total porosity but even with the Fast Fourier Transform, the two-dimensional spectral analysis of a single thin section requires approximately 1 hour computation

time on a large computer. In contrast, a proper optical lens system will produce a Fourier transform and map the power spectrum onto film in a few seconds. A digital approach is more expensive by three or four orders of magnitude. Optical processing methods are especially well-suited for study of radar imagery, air photographs, and gross fabric patterns, as well as microscopic textures in rocks.

Geol. Soc. America, Programs for 1969, Pt. 7, p. 44.

Dingman, Robert J., U.S. Geological Survey, Lawrence, Kansas, and **Angino, Ernest E.**

CHEMICAL COMPOSITION OF SELECTED KANSAS BRINES AS AN AID TO INTERPRETING CHANGE IN WATER CHEMISTRY WITH DEPTH

Chemical analyses of approximately 1,881 samples of water from selected Kansas brines define the variations of water chemistry with depth and aquifer age. The most concentrated brines are found in the Permian rocks which occupy the intermediate section of the geologic column of this area. Salinity decreases below the Permian until the Ordovician (Arbuckle) horizon is reached and then increases until the Precambrian basement rocks are reached. Chemically, the petroleum brines studied in this small area fit the generally accepted pattern of an increase in calcium, sodium and chloride content with increasing salinity. They do not fit the often-predicted trend of increases in the calcium to chloride ratio, calcium content and salinity with depth and geologic age. The calcium to chloride ratio tends to be asymptotic to about 0.2 with increasing chloride content. Sulfate tends to decrease with increasing calcium content. Bicarbonate content is relatively constant with depth.

If many of the hypotheses concerning the chemistry of petroleum brines are valid, then the brines studied are anomalous. An alternative lies in accepting the thesis that exceptions to these hypotheses are rapidly becoming the rule and that indeed we still do not have a valid and general hypothesis to explain the origin and chemistry of petroleum brines. *Chem. Geol. v. 4, 1969, p. 325.*

See also Angino, Ernest E. and Dingman, Robert J., [Same title and abstract] *Geol. Soc. America, Programs for 1969, Pt. 2, p. 1.*

Galle, O. Karmie

CHEMICAL ANALYSIS OF SOME STANDARD CARBONATE ROCKS

Twenty limestone, dolomite and limestone-dolomite blends were analyzed. The samples, which are available from the G. Fredrick Smith Chemical Company of Columbus, Ohio, were issued with an analysis certificate listing values for SiO₂, Fe₂O₃, CaO, and MgO. Additional analyses are reported and results compared with certificate values.

Chem. Geol., v. 5, 1969-70, p. 143.

HOW CHANGES IN TEMPERATURE OF A PREMIX BURNER AFFECT ATOMIC ABSORPTION ANALYSES

Public presentation, Meeting Eleventh Annual Rocky Mountain Spectroscopy Conference, Denver, Colorado, August 5, 1969.

Goebel, Edwin D.; Sweet, Walter C., The Ohio State University, Columbus, Ohio; Hilpman, Paul L.

LATE DEVONIAN AGE OF A MIXED CONODONT FAUNA FROM A CORE IN SOUTHWESTERN KANSAS

Carbonate strata of undoubted Devonian age have not previously been reported from western Kansas, where Mississippian rocks, some with reworked Devonian conodonts, lie unconformably on Middle and Lower Ordovician carbonate rocks in many places. However, conodonts from the upper 18 feet of a 23-foot core between 7,838 and 7,861 feet in the Mobil Oil Company No. 1 Cunningham Estate borehole verify the presence of Devonian rocks in the Voorhees Field of Stevens County, Kansas. On the basis of lithologic correlation by the petroleum industry, the strata in question have been identified as Middle Ordovician Viola Limestone or "Simpson Group."

To a depth of 7,856 feet, acetic-acid insoluble residues from 22 samples in the cored interval yield a mixture of Middle and Upper Ordovician conodonts (e.g., *Belodina*, *Panderodus*) with a few Middle or Upper Devonian specimens (e.g., *Icriodus*, *Palmatolepis*). Specimens exhibit little evidence of reworking. Other genera represented include: *Apatognathus*, *Cordylodus*, *Cyrtionodus*, *Dichognathus*, *Drepanodus*, *Oistodus*, *Ozarkodina*, *Phragmodus*, *Polygnathus*, *Spathognathodus*, and *Trichonodella*. We conclude that the rocks from 7,838 to 7,856 feet are Devonian (probably Upper Devonian), and that they do not represent the Viola or Simpson strata with which they have been identified.

Geol. Soc. America, Programs for 1969, Pt. 6, p. 18.

—, Waugh, Truman C., and Angino, Ernest E.

METALLIC SULFIDE MINERALIZATION IN SOME MID-CONTINENT PALEOZOIC CORES

Acetic acid insoluble residues of Paleozoic cherty carbonate rock cores commonly include some metallic sulfide minerals. The most common minerals are pyrite and marcasite; chalcopyrite, sphalerite, bornite, and galena are present, but less common. Whole-core composite samples of two Mississippian cores from Greenwood County and two Mississippian cores from Greenwood County, Kansas, were analysed by semiquantitative emission spectrography for Pb, Mo, Ni, Cu, Ag, and Zn. Measured concentrations of these elements are comparable with those reported as significant in productive jasperoid from several mining districts in western United States including Oklahoma (Lovering and Hamilton, 1962). The concentration levels of some elements in Kansas cores exceed the average concentrations of these same elements in sedimentary carbonate rocks in the earth's crust as given by Turekian and Wedepohl (1961).

The residues also contain conodonts, which are microfossils composed of apatite. The conodont faunas from the four cores are similar and give an age of late Osagian-early Meramecian. Thus, the host rock of this metallic sulfide mineralization is Middle Mississippian. Mineralization, which is of a similar nature in the four cores, probably is younger than Middle Mississippian. Only more exploratory investigation in the two counties can establish con-

tinuity of mineralization or location of ore-grade minerals.

Geol. Soc. America, Programs for 1969, Pt. 2, p. 12.

Heckel, Philip H.

DEVONIAN TULLY LIMESTONE IN PENNSYLVANIA AND COMPARISON TO TYPE TULLY LIMESTONE IN NEW YORK

In contrast to thick-bedded pure calcilutite dominant in New York, outcropping Tully Limestone in central Pennsylvania consists of shaly calcilutite, appearing both as knobby and platy facies in the field, and calcareous shale. The Tully grades eastward in Pennsylvania to noncalcareous shale and extends southward as a tongue of calcareous shale into West Virginia. In west-central Pennsylvania a dominantly brachiopod fauna in the base of the Tully is succeeded upward by a more diverse assemblage which occurs in this position throughout most of the state. This faunal succession correlates well with that typical of the lower and upper members in New York.

Tully calcilutite contains whole, unabraded skeletal material with roughly similar biological composition in both states. Pennsylvania calcilutite, however, contains a much greater admixture of acid-insoluble terrigenous mud and is intercalated with much more calcareous shale than that occurring in New York. Because Tully carbonate mud was probably allochthonous, its origin must have been north of the New York outcrop. Thus Tully deposition occurred in a quiet sea into which the northern carbonate source and eastern terrigenous clastic source supplied fine sediments of different chemical composition to produce a pure calcilutite in New York grading eastward and southward into Pennsylvania to shaly calcilutite, calcareous shale, and ultimately noncalcareous shale.

Pennsylvania Bur. Topo. & Geol. Survey, Info. Circ. 60, 1969, p. 1.

RECOGNITION OF SHALLOW-MARINE ENVIRONMENTS

Shallow-marine environments encompass a great variety of conditions from shoreline to a depth of about 600 feet. In sedimentary rocks, these environments are inferred most readily from diverse assemblages of fossils whose modern relatives are marine. Some sparse and restricted biotas may represent fully marine environments in which certain factors were unfavorable to many types of organisms. Many unfossiliferous black shales represent a foul environment that supported no benthonic life and are inferred to be marine mainly by stratigraphic relations. Marine environments that lack significant sedimentation would be represented in the record only by a submarine paraconformity.

Recognition of marine subenvironments is possible through direct lithic analogy with distinctive modern sediments of known depositional environments, such as oölite, sea-margin carbonate laminites, and certain organism-controlled features such as reefs. In less distinctive marine facies, subenvironments are difficult to discriminate because visible differences may have resulted from a complex interplay of many variable factors that did not coincide to produce unique subdivisions. Ecologic consideration of fossil assemblages may distinguish clear-water from turbid-

water, or soft-substrate from hard-substrate environments. Petrographic considerations also allow environmental inference. The presence of calcilitite indicates a quiet-water environment that might be either shallow and protected from water agitation by a physical barrier, or deep and protected by water depth itself. The presence of calcarenite composed of whole shells exhibiting little fragmentation or abrasion might indicate only local organic proliferation or lack of dilution by fine sediment. In contrast, calcarenite composed of fragmented, abraded, well-sorted, skeletal grains indicates water turbulence and winnowing of fines, processes which are more probable in shallow water.

Environmental syntheses based on stratigraphic, petrographic, and paleontologic criteria can bring into focus certain aspects of ancient marine environments that are difficult to determine from the record. On a local scale, detailed facies mapping in undeformed rocks may allow detection of original topography that controlled facies changes. On a larger scale, systematic lithic variation along the outcrop of an entire stage of rocks may provide a regional picture of the lateral succession of ancient marine environments across an epicontinental basin. Perhaps one of the best modern laboratories to study analogs of ancient marine epicontinental deposition is the Sahul-Arafura shelf and Gulf of Carpentaria between orogenic New Guinea and cratonic Australia.

Am. Assoc. Petroleum Geologists Bull., v. 53, no. 3, 1969, p. 721.

—, and Cocke, J. M.

PHYLLOID ALGAL-MOUND COMPLEXES IN OUTCROPPING UPPER PENNSYLVANIAN ROCKS OF MID-CONTINENT

A phylloid algal-mound complex is a local to subregional thickening of limestone attributed chiefly to the presence of a distinctive suite of rock types containing leaflike or phylloid algae. Twenty-three such mound complexes are present at or near the southern ends of most limestone units in Missourian and lower Virgilian (Upper Pennsylvanian) rocks exposed in eastern Kansas, northeastern Oklahoma, and northwestern Missouri. Mound complexes are composed of two facies, (1) the mound, consisting primarily of massive algal calcilitite to algal sparite, and (2) mound-associated facies, consisting primarily of thin- and cross-bedded skeletal and oölitic calcarenite capping and flanking the mound. Overlying shale beds thin across the tops of mound complexes. Most mound complexes grade northward into thinner, more diversely fossiliferous, open marine limestone beds, and grade abruptly southward into thin limestone beds and lenses and thick terrigenous clastic strata.

Pennsylvanian phylloid algae are comparable with Holocene calcareous codiacean green algae and coralline red algae, and flourished in shallow sunlit water where they were sediment suppliers and stabilizers. Mounds probably began on topographic highs favorably situated between a region of great clastic influx and the open sea, and grew as the algae proliferated and produced sufficient sediment to compensate for subsidence. Mound growth allowed the algae to continue to flourish in their optimum sunlit environment. Stacking of mound complexes may reflect positive topographic influence of underlying mounds on the sea bottom, and shifts in the

stackings probably resulted from shifts in northward extent of the clastic influx.

Am. Assoc. Petroleum Geologists Bull., v. 53, no. 5, 1969, p. 1058.

Hilpman, Paul L.

DEVONIAN ROCKS IN KANSAS AND THEIR EPEIROGENIC SIGNIFICANCE

Devonian rocks are restricted to the subsurface in Kansas and knowledge of these strata is severely limited. Previous investigations have not included discovery of diagnostic fossils adequate to subdivide the sequence or to permit correlation with distant outcrops in surrounding states.

On the basis of cores from 27 wells, supplemented by more than 2,500 sample, geophysical, and driller's logs, Devonian rocks are subdivided into eight distinct lithologic units. Conodonts recovered from insoluble residues of cores studied indicate that two units are Middle Devonian, three units are early Late Devonian and three units are Late Devonian and Early Mississippian in age. No evidence of Early Devonian rocks was found and widespread erosion is inferred for this time interval.

The distribution and lithologic character of the units indicate that the Middle Devonian seas were restricted to the North Kansas Basin and earliest Late Devonian (Frasnian) seas occupied the Southwest Kansas Basin. Late Devonian (Famennian) and Early Mississippian (Kinderhookian) seas were widespread throughout the state and rocks deposited during this interval lie unconformably on older rocks and are unconformably overlain by younger strata (Osagian Stage).

Epeirogenic interpretations based on this study differ from those of Sloss, Wheeler, and Ham and Wilson.

Unpub. Ph.D. dissertation, Dept. of Geol., Univ. Kansas, 1969, p. 1.

WESTERN MID-CONTINENT STRATIGRAPHY AND THE KASKASKIA SEQUENCE

When the concept of stratigraphic sequences was introduced in 1948, relationships of Devonian and Mississippian rocks in the western Mid-Continent were inadequately known and largely inferred from scattered outcrops and borehole data. The Kaskaskia sequence was defined as a rock stratigraphic unit traceable over major areas of the continent and bounded by unconformities of interregional scope (post-Tippecanoe and pre-Absaroka). The sequence comprises rocks as old as late early Devonian through rocks as young as late (post-Chesteran) Mississippian and represents a major transgression-regression cycle lacking interregional unconformities within its boundaries.

Investigations of Devonian and Mississippian rocks over the past twenty years, aided by detailed micro-paleontological data, have revealed relationships not in accord with the concept of a craton-wide stratigraphic sequence. Evidence suggests that deposition of Devonian rocks was considerably more widespread than previously inferred and a major regression of interregional scope in Mid-Kaskaskian time is indicated by an important and widespread unconformity within the sequence. Stratigraphic relationships further suggest a need for revision of regional structural interpretations in the western Mid-Continent in both time and space.

Geol. Soc. America, Programs for 1969, Pt. 2, p. 14.

URBAN GROWTH AND ENVIRONMENTAL GEOLOGY

Public presentation, Colorado Governor's Conference on Environmental Geology, Denver, Colorado, April 30, 1969.

—, and Stewart, Gary F.

GEOLOGY AND CONCERN FOR THE ENVIRONMENT

No abstract given.

Hwy. Res. Record, no. 271, *Hwy. Res. Board*, 1969, p. 38.

King, Robert J., Department of Geology, The University, Leicester, England; and Merriam, Daniel F.

ORIGIN OF THE "WELDED CHERT," MORRISON FORMATION (JURASSIC), COLORADO

No abstract given.

Geol. Soc. America Bull., v. 80, 1969, p. 1141.

Sackin, Michael J., The University, Leicester, England; and Merriam, Daniel F.

AUTOASSOCIATION, A NEW GEOLOGICAL TOOL

Autoassociation is a computer method of comparing sequences of nonnumeric elements, e.g., of rock-types. The sequence is slid past a replicate of itself. At each position of overlap the number of matching elements is noted and statistics of goodness-of-match are computed.

The method allows several properties to be coded at each position in the sequence. It also allows "unknown," "missing," or "not applicable" elements. Reverse matches are also performed, i.e., with the duplicate sequence reversed in direction.

Autoassociation is used to detect partial repetitions in stratigraphic sequences and to compare regressive and transgressive phases of cyclothem.

Jour. Internat. Assoc. Math. Geol., v. 1, no. 1, 1969, p. 7.

Tien, Pei-lin

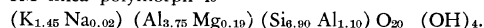
ADDITIONAL INFORMATION ON CLAYS IN PLEISTOCENE DEPOSITS OF NORTHEASTERN KANSAS

No abstract given.

Trans. Kansas Acad. Sci., v. 72, no. 3, 1969, p. ?.

A PURPLE-COLORED 1M MICA CLAY FROM SILVERTON, COLORADO

A purple-colored clay of 1M mica polymorph in association with lead-zinc ore was collected from an abandoned mine dump near Silverton, Colorado. Electron micrographs show that the crystallites of the clay are less than 2μ s in size and have poorly developed hexagonal outlines. Differential thermal and i.r. absorption analyses indicate similarity with those of muscovite. The structural formula of the 1M mica polymorph is



The purple color may be related to trace amounts of manganese in the clay.

Clays and Clay Minerals, v. 17, 1969, p. 245.

—, and Waugh, Truman C.

THERMAL AND X-RAY STUDIES ON EARTHY VIVIANITE IN GRANEROS SHALE (UPPER CRETACEOUS), KANSAS

Samples of earthy vivianite were treated thermally at different temperatures. The intensity of the peaks on their X-ray diffractometer patterns decreases with increasing temperature up to 300°C. Vivianite becomes amorphous after heating to 300°C. A poorly crystalline material is developed between 500°C and 625°C. Above 650°C a mixture of iron (III) orthophosphate ($FePO_4$) and an unknown compound is formed. A reversible polymorphous transformation takes place between 675°C and 750°C. Infrared studies indicate that vivianite may contain hydroxyl ions, and favor to the structural formula of $Fe_{3-x}^{2+} \cdot Fe_x^{3+} \cdot (PO_4)_2 \cdot [(8-x)H_2O \cdot x(OH)]$ for vivianite rather than the conventional formula of $Fe_3(PO_4)_2 \cdot 8H_2O$.

Am. Mineralogist, v. 54, 1969, p. 1355.

Waugh, Truman C.

METHOD OF FIELD SAMPLING USED FOR LOCATING COPPER-BEARING MINERALS IN FOUR SOUTH-CENTRAL COUNTIES IN KANSAS

Public presentation, Meeting Kansas Acad. Sci., Bethel College, North Newton, Kansas, May 2, 1969.

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Part 1. **Short Papers on Research in 1969**, Edited by Doris E. Zeller, p. 1-26, March, 1970.