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This issue of Industrial Minerals Notes includes two items, a report on the rare earth and trace element content of an unusual Hardin County clay and an announcement and brief description of a newly issued map of the sand and gravel resources of Lake County, Illinois.

RARE EARTH AND TRACE ELEMENT CONTENT OF AN UNUSUAL CLAY ON HICKS DOME IN HARDIN COUNTY, ILLINOIS

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Hicks Dome, 7½ miles north of Rosiclare in Hardin County, Illinois, is a high area both structurally and topographically. Former igneous activity in the area is shown by the presence of two mica peridotite dikes and three occurrences of explosion breccia. A strongly radioactive, yellow, silty clay in the central part of the dome contained the largest uranium content (0.023 percent U_3O_8) found in some 175 samples from Hardin County that were tested (Bradbury et al., 1955). Fractionation of samples of the clay revealed that the greatest radioactivity was concentrated in the clay-size material.

The radioactivity of the yellow material (up to 0.251 percent eU) was much greater than could be accounted for by the amount of U_3O_8 shown in the analyses. Therefore it was suspected that thorium, the other common radioactive element, was present. As most thorium minerals contain rare earths, a group of much sought-after "space-age" metals, it was considered possible that rare earths also might be present.

In order to explore the extent and character of the main radioactive zone, a bulldozer trench was dug in the NW¼ SW¼ sec. 30, T. 11 S., R. 8 E., by W. G. Reynolds and associates of Louisville, Kentucky, under a cooperative agreement with the Defense Minerals Exploration Administration. R. D. Trace of the U. S. Geological Survey investigated the results of the operation for the DMEA. Both events occurred in 1956.

The yellow clay, as exposed in the trench, occurred as streaks and pockets in a vertical, vein-like body composed chiefly of fragments of rock in a silty, clayey matrix. The material on either side of the vein-like body consisted of essentially flat-lying beds of chert and siltstone with which was associated much red clay. The bulk of the vein material was stained brown to dark brown by limonite and manganese oxide, and the dark color facilitated following the vein in its sinuous course along the floor of the trench.

The fragments of rock in the vein were chert, siltstone, chert breccia cemented by finely granular quartz, and a fine-grained quartzose rock. The latter consisted of scattered round quartz grains about 1 millimeter in diameter in a fine-grained quartz matrix. It is not clear whether the rock is quartzite or a silicified limestone.

The general appearance of the material in the trench suggested a greatly distorted residuum from the weathering of cherty limestone. The presence of chert breccia among the included rock fragments may indicate faulting or other deep-seated disturbance or merely collapse into a solution cavity along an intensely jointed zone. However, several known occurrences of chert breccia "dikes" in the Hicks Dome area suggest a cause more deep-seated than solution collapse.

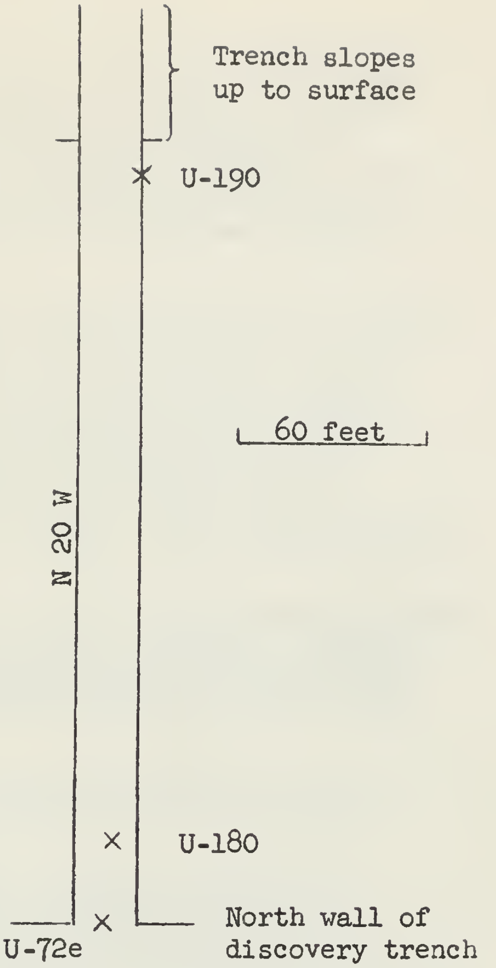

Fig. 1. - Sketch map of exploration trench, Hicks Dome, Hardin County, Illinois.

The origin of the highly radioactive yellow clay is even more questionable. It consists of the same components found in the rest of the vein material -- clay, silt, and fragments of chert, fine-grained quartzose rock, and fine granular quartz -- but with a much smaller proportion of chert fragments than in the rest of the vein. In addition, the grain size of the yellow material is much finer, with most of the material passing a 10-mesh screen.

The color of the yellow mixture is similar to that of weathering residuum from younger formations elsewhere in the area, and it was felt that the yellow streaks and pockets could represent weathered material washed into the fracture zone from overlying formations now removed by erosion. However, the yellow material shows no sorting or laminations such as might be expected in water-transported material. Other possibilities are that the unweathered parent rock of the yellow mixture fell from above into a solution cavity or was forced up from below by a subterranean explosion such as is thought to have created other breccia occurrences on Hicks Dome (Bradbury et al., 1955; Brown et al., 1954). At present, not enough facts are known to postulate a definite origin for the yellow material or its radioactivity.

The quantity of yellow clay is limited so far as can be told from the information presently known about it. However, because the clay was the most radioactive of the Hardin County samples and thus unusual, and because it appeared a possibility that the clay's radioactivity was due to thorium, it was considered desirable to determine its trace element and rare earth content. Three samples taken from different parts of the bulldozer trench were analyzed with the results indicated below.

Sample U-72e was taken from a 14-inch wide vertical vein-like exposure of the yellow radioactive material in the north wall of the discovery trench (fig. 1), a bulldozer excavation that crossed the vein nearly at right angles and served as the starting point for the main north-south exploratory trench which roughly follows the vein. Sample U-180 is from the floor of the main trench, 25 feet north of the discovery trench. Sample U-190 represents a pocket of the yellow material in the east wall of the main trench, approximately 250 feet north of the discovery trench.

Table 1 shows the trace element content as determined spectrochemically. Twenty-three elements were sought. Ten, if present at all, occurred in amounts too small to be detected. The amounts of the 13 elements which were detected are small in all samples and are not known to indicate unusual or commercially significant amounts of any of the elements found.

Table 2 gives data on rare earth content which also was determined spectrochemically.

Monazite (a phosphate of the cerium metals) and bastnaesite (a fluocarbonate of the cerium metals) are the principal sources of rare earths (Mertie, 1960). The mean composition of the rare earths in monazite and bastnaesite as determined by the U. S. Geological Survey (Mertie, 1960), is shown in percent by weight in table 3.

In the United States monazite is produced as a by-product of other mineral processing operations in Flordia, South Carolina and Idaho; bastnaesite is produced in California (Lewis, 1958). Engineering and Mining Journal states that during 1958 "large contract prices for monazite remained unchanged at about $250 per net short ton delivered for ore containing 6 percent ThO_2 and 45 percent rare earth oxide. There was considerable softening in prices for small lots of imported monazite, and purchases were made in the range of $100 to $200 per short ton delivery" (Kremers, 1959).

The total rare earth content of the samples U-72e, U-180 and U-190, table 2, in percent by weight is 3.6, 2.9, and 3.4 percent. It is evident that considerable upgrading of the raw material would be required to bring it to commercial grade. Methods of upgrading, whether they are commercially feasible, and whether a commercial grade could be produced from the clay are matters to be worked out. However, before such matters are investigated a sizable deposit of suitable raw material should be demonstrated. From present knowledge the existence of such a deposit in the Hicks Dome area appears questionable. In view of the many problems involved, the commercial possibilities of the yellow silty clay of Hicks Dome as a source of rare earths are uncertain.

REFERENCES

Bradbury, J. C., Ostrom, M. E., and McVicker, L. D., 1955, Preliminary report on uranium in Hardin County, Illinois: Illinois Geol. Survey Circ. 200.

Brown, J. S., Emery, J. A., and Meyer, P. A., 1954, Explosion pipe in test well on Hicks Dome, Hardin County, Illinois: Econ. Geology, v. 49, p. 891-902.

Kremers, Howard E., 1959, Rare earths: Engineering and Mining Journal, v. 160, no. 2, p. 106.

Lewis, Walter E., 1959, "Rare earth minerals and metals" in U. S. Bureau Mines, Minerals Yearbook, 1958, vol. 1, p. 889.

Mertie, John B., 1960, Chapter on "Monazite and related minerals" in Industrial Minerals and Rocks: American Inst. Mining, Metallurgical, and Petroleum Engineers, New York, p. 623-25.

TABLE 1. - Trace Elements in Clays*†
(Percent by weight)

	Sample U-72e	Sample U-180	Sample U-190
Strontium	0.2 - 0.1	0.2 - 0.1	0.2 - 0.1
Cobalt	n.d.	0.001	0.002 - 0.001
Nickel	0.002	0.002	0.05 - 0.02
Zirconium	0.03 - 0.02	0.03	0.03
Silver	n.d.	n.d.	n.d.
Titanium	0.05	0.05	0.05
Vanadium	0.02	0.02 - 0.01	0.02
Beryllium	0.002 - 0.001	0.005 - 0.002	0.002 - 0.001
Bismuth	0.001	0.002 - 0.001	0.002 - 0.001
Lead	0.01 - 0.008	0.03 - 0.01	0.03 - 0.01
Chromium	n.d.	n.d.	n.d.
Manganese	0.1	0.1	0.1

* Copper was detected in all samples but estimation of amount was impossible because of high blank.

Elements sought but not detected with limit of detection - Mo (.001%), Ge (.001%), Sn (.001%), Cd (.01%), Sb (.01%), Zn (.02%), Tl (.01%), As (.04%), Ga (.01%) and Nb (.01%).

† Analyses by K. Nagashima in the laboratories of the State Geological Survey.

n.d. - Not detected; less than the limits of detection.

TABLE 2. - Rare Earths in Clays*†
(In parts per million)

Element	Calculated compound reported	Limit of detection (**)	Sample U-72e	Sample U-180	Sample U-190
Cerium	CeO_2	100	15,000	9,000	12,000
Dysprosium	Dy_2O_3	5	600	Tr	nd
Erbium	Er_2O_3	5	300	300	100
Gadolinium	Go_2O_3	20	1,000	1,000	1,000
Holmium	Ho_2O_3	2	60	100	100
Lanthanum	La_2O_3	10	8,400	7,800	11,000
Neodymium	Nd_2O_3	50	5,000	6,000	8,000
Praseodymium	Pr_6O_{11}	20	200	100	100
Ytterbium	Yb_2O_3	.05	5	9	8
Yttrium	Y_2O_3	20	6,000	5,000	2,000

* For analysis, suitable amounts of these concentrates were mixed with a CuO - graphite matrix.

† Analyses by Juanita Witters in the laboratories of the State Geological Survey.

n.d. - Not detected; less than the indicated limit of detection.

1000 parts per million equal 0.1% by weight.

** Uncertainty is estimated to be $\frac{1}{2}$x - 2x except for La and Y for which the uncertainty is estimated to be 20%.

TABLE 3. - Mean Composition of Rare-Earths in Monazite and Bastnaesite (Mertie, 1960)

	Monazite	Bastnaesite
La_2O_3	21.7	32.6
CeO_2	45.5	49.0
Pr_6O_{11}	5.1	4.4
Nd_2O_3	19.2	12.6
Sm_2O_3	4.0	1.1
Gd_2O_3	1.9	0.2
Others	2.6	0.1

MAP OF SAND AND GRAVEL RESOURCES OF LAKE COUNTY, ILLINOIS

A new map entitled, "A Preliminary Map of the Sand and Gravel Resources of Lake County, Illinois," by George E. Ekblaw and David A. Schaefer, is now available. It has been compiled from unpublished maps of the glacial geology of Lake County that have been available for reference at the offices of the State Geological Survey and from published geological maps of the Wheeling and Highland Park quadrangles that cover the southeast part of the county.

On the new map, which is on the scale of 1 inch equals 1 mile, the geological information has been interpreted in terms of sand and gravel resources. Four types of deposits are present.

Hill or ridge areas known or believed to be underlain at many places by sand and gravel occur chiefly in the western tier of townships of the county, although some deposits occur elsewhere. Technically, the deposits include kames, eskers, and morainal hills.

Largely restricted to the valleys of DesPlaines and Fox Rivers are outwash deposits of sand and gravel that were laid down by glacial floods. They are described as areas known or believed to be underlain by sheetlike deposits of sand and gravel in some places. In and adjacent to the DesPlaines River the sand and gravel deposits rest on an uneven floor of glacial clay and therefore vary in thickness. Low hills and ridges in the area are bars built by glacial DesPlaines River and are likly to be made up of coarser sand and gravel than occur in the flatter parts.

Also along the DesPlaines River valley and comprising an elongate north-south tract through Libertyville are lowland areas known or believed to be underlain by alluvial deposits of sand and gravel at some places. These deposits are thought to be generally thin.

Dune and beach deposits of sand occur locally in the Zion-Waukegan area in the northeast part of the county.

The resources map of Lake County has been prepared as a tracing. Ozalid prints of the tracing will be available for 50 cents each from the State Geological Survey, Urbana, Illinois on and after July 20, 1960. Remittance may be in postage stamps.