absorption, diffusion, and decay of the isotope.

Figure 2 is part of an autoradiograph obtained by this method. The dark background area is the uniformly labeled soil. The whiter areas are soil areas from which rubidium-86 has been removed by absorption into the plant root. The dark lines are caused by rubidium-86 concentrated in the tips and vascular systems of the roots, which has not yet been translocated to the plant top.

Because of the construction of the box, photographs, as well as autoradiographs, could be made of the roots growing in the soil. Both by visual observations of the autoradiographs and photographs and by densitometer tracings of the auotradiographs, the following conclusions have been drawn about the pattern of rubidium-86 uptake by the corn plant.

For corn from 0 to 3 weeks old. rubidium-86 absorption occurred initially through the root tip, and rubidium was translocated into the corn plant. Subsequently, continued uptake occurred all along the root, depleting the soil of rubidium-86 almost entirely in the immediate vicinity of the root. Diffusion of rubidium-86 also occurred, which replenished the absorbed rubidium-86. Diffusion was observed by cutting a root, thereby killing it, and finding that the area of absorption was refilled with rubidium-86 within 9 days.

By using the technique described in this article, it was possible to establish the actual pattern of rubidium-86 absorption from the soil by corn roots. This technique is being applied to a further investigation of the relationships between plant roots and the soil (*3*).

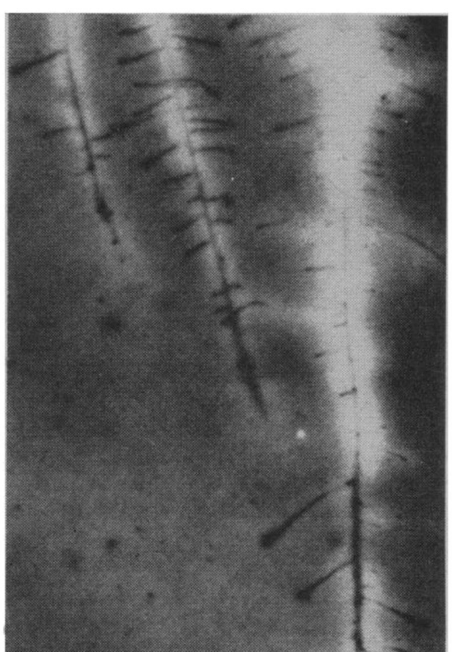

Fig. 2. Autoradiograph showing the removal of rubidium-86 from soil by the roots of 12-day-old corn plants (approximately two thirds of the actual size).

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2. The assistance of Dr. R. G. Langston, of the Horticulture Department, in advising on autoradiographic techniques is gratefully acknowledged.
3. This investigation was part of a thesis submitted in partial fulfillment of the requirement for the Ph.D. degree by the senior author.

5 December 1960

Coesite from Wabar Crater, near Al Hadida, Arabia

Abstract. The third natural occurrence of coesite, the high pressure polymorph of silica, is found at the Wabar meteorite crater, Arabia. The Wabar crater is about 300 feet in diameter and about 40 feet deep. It is the smallest of three craters where coesite has been found.

Since the discovery of natural coesite, the high-pressure polymorph of silica (*1*), at Meteor Crater, Arizona, the search for it in sintered materials of impact and other possible origins, such as tectonic or volcanic, has been continued in the laboratories of the U.S. Geological Survey. The work is a part of a program of crater investigations sponsored by the National Aeronautics and Space Administration. During the course of this work, a second occurrence of natural coesite was found in *suevit*, a tuff-like rock, from the Rieskessel in Bavaria, Germany (*2*). In this paper (*3*) we report a third occurrence of natural coesite, from the iron meteorite impact crater of Al Hadida.

The Wabar crater near Al Hadida (21°30′N, 50°28′E) is in a quartose sandstone of unknown age, partly buried by drift sand in east-central Arabia. It is circular in shape, and according to Philby (*4*) it is about 300 feet in diameter and about 40 feet deep. According to Spencer (*5*) large amounts of black glass (the Wabar glass), partly vesicular and partly dense, with inclusions of fractured white sandstone, are found at the crater. The presence of silica glass is also mentioned by Spencer.

Two specimens of coesite-bearing material collected from the Wabar crater by Virgil Barnes, Bureau of Economic Geology, University of Texas, have been examined in the U.S. Geological Survey laboratories. One specimen consists of white siliceous material about 1 cm across, enclosed in black glass; the second was a piece of fractured sandstone about 4 cm across (Fig. 1).

Both specimens were crushed to reduce them to individual mineral grains, and fractured quartz grains were handpicked. These, as well as bulk specimen powders, were studied by x-ray diffraction methods. Film patterns of the bulk powders showed only one very weak reflection at 28.85 2θ (Cu $K\alpha$), which indicates the possible presence of coesite.

The x-ray film of the hand-picked, fractured quartz grains showed many more weak reflections of coesite than that of the bulk sample. We have since been able to separate relatively pure coesite and have obtained an x-ray pattern with no indication of quartz. The coesite was separated by treating 5.4 g of minus 270-mesh material with 300 ml of a water solution of 5 percent hydrofluoric acid and 5 percent nitric acid at room temperature for 3 days (coesite is considerably less soluble than quartz and glass in weak solutions of hydrofluoric acid); the product was filtered, and the treatment was repeated on the residue for an additional 2 days; then it was filtered again, and the relatively pure coesite was washed and dried.

X-ray patterns of coesite from Al Hadida agree in every detail with those of synthetic coesite and natural coesite from Meteor Crater, Arizona. Optically it is indistinguishable from the Meteor Crater coesite; it is extremely fine, with grains generally about 5μ or less. It has a mean index of refraction of 1.595 and very low birefringence.

The Wabar crater is by far the smallest of the three craters at which coesite has been found. It is estimated that the specimens from Al Hadida contain about 1 percent coesite. Because the

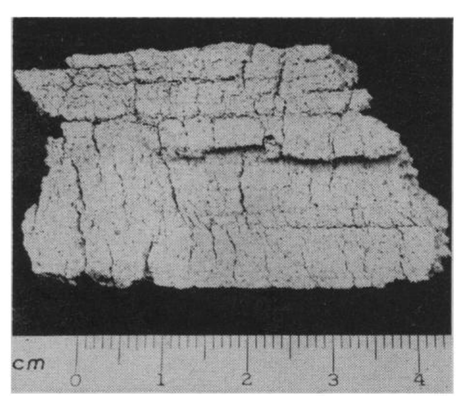

Fig. 1. Fractured coesite-bearing sandstone, showing bedding and steeply inclined fractures, from the Wabar crater.

size of a crater increases with the total energy released by impact, the presence of coesite at the Wabar crater suggests that, in siliceous rocks, impact craters of this or greater size should contain coesite. The Wabar crater is comparable in size to a crater made in alluvium by the explosion of a nuclear device at a depth of about 67 feet. This device had a yield of an equivalent of 1.2 kilotons TNT (*6*).

Natural coesite has thus far been found only in materials associated with craters of presumed impact origin where shock pressures exceeding 20 kb are thought to have occurred. We shall continue to check other possible, though unlikely, sources of coesite in deformed rocks of tectonic and volcanic origin. The evidence so far, however, supports the conclusion (*1*) that coesite is a good indicator of craters formed by impact (*7*).

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7. We are indebted to Dr. Virgil Barnes for the use of his Al Hadida specimens and to Edward Henderson of the U.S. National Museum who made the specimens available to us. We also wish to thank the Arabian American Oil Company for the oblique aerial photograph of the Wabar crater.

7 February 1961

Active Transport of Calcium by Rat Duodenum in vivo

Abstract. In studies of the living rat, it was observed that ionic calcium is transferred against a concentration gradient and an electropotential gradient by the duodenal membrane; this would constitute evidence for the active transport of calcium in intestinal absorption and corroborates earlier observations made in vitro. The significance of this process in regard to total calcium absorption is unknown at present.

Recently, Schachter and Rosen (*1*) have postulated the existence of an active transport system for calcium by the rat intestine; they used everted duodenal sacs in vitro. The evidence that suggested active transport was primarily (i) that calcium (labeled with Ca^{45}) was transferred against a concentration gradient and (ii) that the process was inhibited by metabolic poisons. Verification of these in vitro observations was reported by Rasmussen (*2*) in studies of the effect of the parathyroid on calcium transport, by Wasserman (*3*) in studies of the metabolic basis of calcium and strontium discrimination, and by Harrison *et al.* (*4*) in studies of the effect of vitamin D on calcium absorption. It was further shown that the degree of calcium transport was correlated with the physiological need for this ion.

Table 1. Calcium fluxes across rat duodenum and a comparison of observed and theoretical flux ratios of calcium. Values for flux represent mean plus-or-minus standard error of the mean of five to six animals. Total plasma calcium was 2.6 ± 0.5 mmole, the estimated ionic plasma calcium was 1.3 mmole, and the mean potential difference between lumen and plasma was − 8.1 mv.

Infused Ca (mmole)	Calcium flux (μmole/cm hr)			Ratio Ca^{++}_{lumen}/Ca^{++}_{plasma}	Flux ratio (Ca efflux/Ca influx)	
	Efflux	Influx	Net efflux		Theoretical*	Observed
0.30	0.043 ± 0.004	0.025 ± 0.003	0.018 ± 0.002	0.23	0.12	1.8 ± 0.3
0.56	.069 ± .005	.021 ± .008	.048 ± .005	.43	.23	3.2 ± .5
1.10	.11 ± .01	.034 ± .008	.076 ± .005	.85	.45	3.3 ± .9
1.97	.17 ± .02	.015 ± .004	.16 ± .01	1.52	.81	11 ± 1

* Calculated from diffusion equation of Ussing (*8*), as follows:

$$(\text{Ca efflux}/\text{Ca influx}) = (C_L/C_P) \exp ZF(\psi_L - \psi_P)/RT,$$

where C_L and C_P = concentration of ionic Ca in lumen and plasma, respectively; Z = ionic charge; R = gas constant; F = Faraday; T = absolute temperature; and $\psi_L - \psi_P$ = potential difference between lumen and plasma.

Since the in vitro biological preparation is certainly nonphysiological, the argument has been put forth that observations thereon cannot be taken to mean that the active transport of calcium occurs in the intact animal. Also, in the above in vitro studies, the potential differences across the membrane were not measured. It was important, therefore, to examine in detail the kinetics of calcium transfer across the intestine of the living animal and to evaluate transport by accepted, classical procedures. The present study (*5*) was undertaken for this purpose; it was based upon the technique of Curran and Solomon (*6*).

Male albino rats (Carworth) weighing 200 to 250 g were fasted overnight before use. Surgical anesthesia was produced with sodium pentobarbital (about 6 mg/100 g body weight); the animal was maintained in this state by periodic injections of the drug. After laparotomy, an incision was made in the gastric wall, and polyethylene tubing was inserted through the stomach into the upper duodenum; the tubing was tied in place with suture. The outflow cannula and a saturated potassium chloride agar bridge were inserted into the duodenal lumen at a distance of 10 to 15 cm from the pylorus; they were then tied in place. The other agar bridge was placed in the peritoneal cavity adjacent to the duodenum. The agar bridges were led into calomel electrodes which, in turn, were attached to a sensitive electropotentiometer. The potential across the membrane was measured both directly and by determining the voltage necessary to null the measured potential. Measurements were made of the potential gradient between blood (carotid arterial and jugular venous blood), peritoneal cavity, and lumen. It was observed that the potential gradient between lumen and blood and between lumen and peritoneal cavity differed only by about 1 mv; therefore, the lumen-peritoneal potential closely approximated that of the lumen-plasma potential.

To test further the reliability of the measurement, the potential was determined when both electrodes were placed within the peritoneal cavity; here, the observed potential gradient ranged between +2 and −2 mv, indicating errors due to placement differences and differences in electrodes. Further, it was found that the potential dropped to zero when the animal was killed with one electrode in the lumen and the other electrode in either the blood stream or in the peritoneal cavity. Thus, any observed potential greater than +2 mv or less than −2 mv during the infusion studies was taken as an indication of a true potential across the membrane.

The intestine was left exteriorized and kept moistened by covering with saline-saturated absorbent cotton. The animal with attached electrodes and tubing was placed within an incubator maintained at 37°C.

The infusion solutions were made by dissolving the appropriate amount of calcium chloride (Mallinckrodt) in sterile, nonpyrogenic physiological saline. Radioactive calcium (Ca^{45}) was added at levels of 0.5 to 2.0 μc/ml. The fluids were infused in order of increasing strength at controlled rates, usually 0.0388 ml/min, by the use of a motorized syringe pump (Harvard Apparatus Co.). Before collections were made, sufficient fluid was passed through the intestine to assure that the previous solution had been completely