factor will obscure the difference in activity due to other factors. A pH two or more pH units below pK was recommended (*8*) for such measurements, but this may not always be practicable. Thus there are few organisms that could be used to measure the activity of a carboxylic acid of pK 4 at a pH of 2. In such a case it may be best to make the measurements at a convenient pH, say, pH 7, and then use the quantitative relationship between pH and activity shown in Fig. 1 to make a correction for the effects of the varying degrees of dissociation of the different compounds. It may be noted that an alternative form of correction has been used by some authors (*9*), who measured activity in terms of the concentration of undissociated molecules instead of the total concentration; this procedure is open to criticism because it is based on the unjustified (*1*) assumption that only undissociated molecules are active.

References

1. SIMON, E. W., and BEEVERS, H. *New Phytologist*, Pt. 1 (in press).
2. BEEVERS, H., and SIMON, E. W. *Nature*, **163**, 408 (1949).
3. SCHROEDER, E. F., WOODWARD, G. W., and PLATT, M. E. *J. Biol. Chem.*, **100**, 525 (1933).
4. KELLY, S., and AVERY, G. S. *Am. J. Botany*, **36**, 421 (1949).
5. DAGYS, VON J., and KAIKARYTE, O. *Protoplasma*, **38**, 127 (1943).
6. BENNET-CLARK, T. A. *Ann. Rev. Biochem.*, **18**, 639 (1949); THIMANN, K. V., and BONNER, W. D. *Ann. Rev. Plant Physiol.*, **1**, 75 (1950).
7. SIMON, E. W., and BEEVERS, H. *New Phytologist*, Pt. 2 (in press).
8. SIMON, E. W., and BLACKMAN, G. E. *Symposia Soc. Exptl. Biol.*, **3**, 252 (1949).
9. BONNER, D. M. *Botan. Gaz.*, **100**, 200 (1938–39); WENT, F. W., *Proc. Acad. Sci. Amsterdam*, **42**, 731 (1939); CAVILL, G. W. K., PHILLIPS, J. N., and VINCENT, J. M. *J. Soc. Chem. Ind. (London)*, **68**, 12 (1949).

Loose Carbonate Accretions from Carlsbad Caverns, New Mexico

Donald M. Black

Carlsbad Caverns National Park, New Mexico

The external shapes of loose carbonate accretions often indicate the type of core or "seed" around which they have grown. Three distinctive groups of loose accretions have been observed in Carlsbad Caverns. Undoubtedly more will be recognized as this study progresses; however, it is believed that these three represent the greater percentage of loose carbonate accretions to be found in the caverns. For simplicity, they will be referred to as the "spherical," "prismatic," and "irregular" groups, as shown in Fig. 1.

Spherical accretions. Small spherical accretions, or "cave pearls," usually have a very small calcareous fragment as a seed (II); this fragment is seldom more than 10% of the pearl's volume. Apparently, each accretion layer is nearly consistent in thickness over the entire surface of the previous layer. Pearls larger than a centimeter in diameter do not necessarily have a small seed.

Prismatic accretions. This group contains the forms

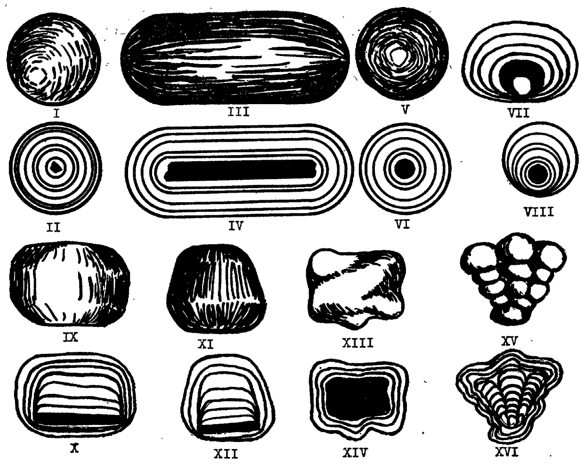

FIG. 1. I, Cave pearl, × 1.5. II, Cross section. Angular spot in center represents sand grain; concentric circles, series of minute, irregular growth rings. III, Accretion with stalactite core, × 1.5. IV, Transverse section. Heavy shaded center represents stalactite; lines represent series of minute, irregular growth increments. V, End view. VI, Cross section. Heavy shaded center represents stalactite; concentric circles represent series of minute, irregular growth increments. VII, Cross section of nonturning accretion with a stalactite fragment core (dark center), × 1.5. VIII, Cross section of nonturning accretion with a cave pearl core (dark circle), and growth increments, × .75. IX, Truncated prism accretion with a scale core, × .75. X, Cross section showing scale core (dark area), and growth increments. XI, Truncated cone accretion with scale core, × .75. XII, Cross section showing scale core (dark area), and growth increments. XIII, Irregular accretion with bedrock core, × .75. XIV, Cross section showing bedrock core (dark area). XV, Irregular accretion with "popcorn" fragment core, × .75. XVI, Cross section showing "popcorn" fragment as a triple series of vertical growth increments.

having fragments of stalactites or flat fragments as a core (III–XII). The stalactite core usually has the accretion layers concentric with its diameter (VI); however, at each end of the stalactite fragment the accretion growth tends to seal the ends and become convex in outline (IV). A scale or flake permits a faster rate of growth on its top surface than on the side or bottom (X, XII). After growth once stabilizes, the accretion formed around a scale or flat fragment will resemble a truncated cone or prism (IX–XII).

Irregular accretions. Irregularly shaped accretions usually have formed around fragments of bedrock or pieces of broken formations (XIII–XVI).

Spheres or pearls. These require constant turning while growing; if rotation ceases and growth continues, they will become elongated. Dripping water that causes rotation is most conducive to the forming of pearls; core or seed of such an accretion is usually a very small calcareous fragment.

Prismatic. Very elongated accretions usually form around a section of a broken stalactite. If this section is round in cross section, it rolls readily and forms concentric rings of growth (VI). If it cannot rotate, one side will be flat (VII, VIII).

Truncated prisms or cylinders represent growth on a flat fragment; many such fragments peel or spall from decomposing stalagmites. Growth on these fragments is primarily upward from the top surface; very little growth accumulates on the sides or bottom as long as the scale cannot turn edgewise (center, X, XII).

Irregular. Accretions with very irregular form usually reflect the shape of core on which they have formed. Fluted pieces of bedrock, and fragments of formations comprise the cores of most irregular accretions.

Associations of Rust and Virus Infections

C. E. Yarwood

Division of Plant Pathology, University of California, Berkeley

Attempts to transmit virus infections of plants by fungus and bacterial and nematode pathogens have generally been negative (*1, 2*), though the work of Hedges (*3*) may be an exception. Extracts of fungi usually inactivate viruses (*4*), no virus infection of fungi is clearly established, and no plant virus has increased with certainty *in vitro*. Therefore the greater susceptibility to several viruses of rust-infected than normal tissues may be of interest.

Interaction of viruses of tobacco mosaic (TMV), tobacco ring spot, tobacco necrosis, alfalfa mosaic, cucumber mosaic, white clover mosaic, beet mosaic, beet curly top, squash mosaic, and potato latent mosaic, with the uredinial stages of rusts of bean, sunflower, snapdragon, or beet have been tested. Positive evidence of association of the first five viruses with bean rust (*Uromyces phaseoli* on *Phaseolus vulgaris*), of the first two with sunflower rust (*Puccinia helianthi* on *Helianthus annuus*), and of the second with snapdragon rust (*Puccinia antirrhini* on *Antirrhinum majus*) has been obtained.

Bean plants about 8 days old and in the primary leaf stage were inoculated with rust race 1 by applying a suspension of uredospores with a brush to the lower surface of one half of each leaf and incubating overnight in a moist chamber. About 3 days later the leaves were inoculated with virus by applying with a firm brush a suspension of virus-infected tissue to the carborundum-dusted upper surface of one leaf of the pair of leaves on each plant. After inoculation the virus extract and carborundum were washed from the leaf surface.

On nonrusted tissues, virus symptoms usually appeared as noninvasive, necrotic local lesions in 3 days when tobacco mosaic, tobacco ring spot, tobacco necrosis, or alfalfa mosaic were inoculated on bean, but no specific local symptoms resulted from inoculation of cucumber mosaic on bean or of TMV or ring spot on sunflower leaves.

When TMV was inoculated on beans with well-separated rust pustules, necrotic rings formed around some of the pustules (Fig. 1). With closely contiguous rust pustules TMV infection formed few necrotic lesions, and did not form necrotic rings around the individual pustules. The virus was invasive in such rusted tissue, through which it moved about 1 mm per day, and formed a necrotic ring or margin around the entire rusted area. In virus-infected tissues, rust sporulation was reduced, and the tissue died sooner than in the absence of rust infection. The viruses of tobacco ring spot, tobacco necrosis, and alfalfa mosaic produced symptoms in rusted tissue somewhat like those of tobacco mosaic virus.

With cucumber mosaic virus on bean, circular necrotic lesions formed only in rusted tissues.

With TMV or tobacco ring spot virus on sunflower leaves no local lesions formed in the rusted or nonrusted areas, but assay of these tissues showed virus in both—more in the rusted than in the nonrusted areas.

Virus concentration in leaf tissues was measured by the local lesion method (*5*). In five trials the number of local lesions per square centimeter formed on *Nicotiana glutinosa* was 0, 0.02, and 0.08 for concentrations of 0.01, 0.1, and 1%, respectively, of tissues from TMV-inoculated nonrusted bean, and 0.3, 4.1, and 8.0 for 0.001, 0.01, and 0.1%, respectively, of tissues from TMV-inoculated rusted bean. For comparison the numbers were 2.2, 7.9, and 15 lesions for 0.0001, 0.001, and 0.01%, respectively, for tissues from tobacco systemically infected with TMV. When these data are plotted on log log scales, only the data for systemic TMV in tobacco gives the expected straight line, and it is therefore difficult to compare the virus concentration for these three types of tissues. If extrapolation of values is permitted, however, the writer believes, on the basis of the above

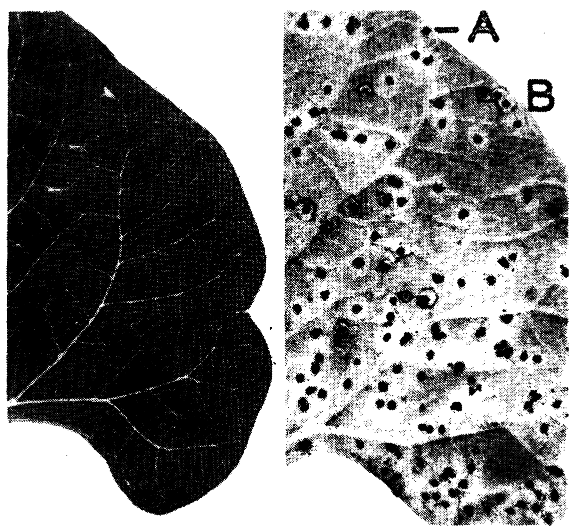

FIG. 1. Left, upper surface of pinto bean leaf showing ordinary local lesions caused by infection with tobacco mosaic virus. Right, lower surface of pinto bean leaf inoculated lightly with rust on May 12, and inoculated with tobacco mosaic virus on May 15; photographed May 31. Infection with tobacco mosaic virus appears as necrotic rings around some of the rust pustules: *A*, ordinary uredinial pustule without virus infection; *B*, a group of four uredinial lesions infected with virus. The virus infection apparently started in upper left pustule and has proceeded to lower right pustule, invading all contiguous pustules and forming progressively wider necrotic rings around the rust pustules. Similar symptoms were less distinctly seen on the upper leaf surface.