(1980a), Siffre (1981), Weng (1981), Zhu et al. (1982), Hill (1983b), Revel (1983), Melegari (1984), Schnitzer and Forstmayer (1984), Mouret (1985), Hill (1987b), Ford (1988), Zambotto (1988), Ford, T. (1989), Ford and Williams (1989), Lino (1989), Horii et al. (1990), Vaqueiro (1992), Cai et al. (1993), Finlayson and Li (1993), Mouret (1993), Borsato (1994), Mocchiutti and Trevisani (1994), Veni (1994a), Hammerschmit et al. (1995), Oelze (1995), Suh (1996).

Rings, Cave

Cave rings (sometimes also referred to as splash rings or circles of calcite) are a speleothem type first observed in the Lip Service Passage of Lechuguilla Cave, New Mexico by Davis (1989e). He called the speleothem a "raised splash ring" and described them as being 5 cm wide and nearly 2.1 m in diameter.

Torres Capote et al. (1990) later described cave rings from the Gran Caverna de Santo Tomás, Cuba, calling them "círculos concéntricos reconstructivos." He described them as symmetrical, 0.8 to 1.4 m in diameter, mineral rings formed in a soft-dirt floor surrounding hollow stalagmites. Rings also occur in the Lapa do Bezerra Cave, Sâo Domingos karst area, Brazil (Fig. 85). In Santo Tomás the rings are up to 3-4 cm thick and normally consist of an admixture of calcite and rhodochrosite. The color of these rings is brown to dark gray due to the presence of rhodochrosite, while that of the stalagmites is pale-gray to yellow-brown. Perfectly circular rings occur on flat floors in the cave, but if the floor is sloping, the ring shape progressively changes into an elliptical form with the longer diameter along dip.

The Gran Caverna de Santo Tomás and Lapa do Bezerra rings are the best developed of the reported localities, but other caves display less-perfect rings. Rings covering dust or mud floors have been described in the Banarat caves, Sarawak, Malaysia (Meredith et al., 1992) and in Sorell Cave, Sardinia (Montanaro, 1992). The Banarat rings are still in the very early, erosional stages. Other ring locations are in the Lapa do Bezerra, São Domingos, Goiás, Brazil (Auler, 1993); in Lapa Vermelhi I Cave, Minas Geraia, Brazil (A. Auler, pers. comm.); and possibly in Wind Cave, South Dakota (R. Wolfert, pers. comm.). At least five "calcite circles" exist in Lapa do Bezerra (Auler, 1993): these rings range from 40 cm to 118 cm in diameter, 9.5 to 12 in width, and 7 to 10 cm in height.

The dimension of all reported rings is similar (0.8-2 m in diameter), except those observed in Sorell Cave which are much smaller (15-25 cm in diameter, maximum; Fig. 86). This difference in diameter reflects a difference in genetic mechanism. The genetic mechanism for the Gran Santo Tomás rings (and other rings of similar dimension) is analogous to the formation of ejecta rings around meteorite craters — that is, by material being ejected into place (in this case, spray droplets created by splash from ceiling drips hitting central stalagmites or the floor) (Fig. 87). The direction of the spray droplets is random, but the spray angle is not. It was shown by Torres Capote et al. (1990) that an angle of 45° is the most probable from a statistical point of view and allows the droplets to cover the longest distance from the center of the splash point. This distance (and thus the radius of the ring) is determined by the kinetic energy of the droplet, which in turn is determined by the height of the roof. In the early stages of ring development, the spray process is merely erosional — undersaturation of the droplets causes a circular depression 2-3 mm deep in the sand-mud floor where the soft dirt is scattered and accumulates as a sharp, circular, ejecta deposit just beyond the depression. Later, saturated spray solutions uplift by capillary action onto the top of the sharp circle, and it is there that carbonate material is deposited as speleothem rings. The very low drip frequency (three minutes between each drip) is an important factor in the development of rings, because a droplet must completely deposit its mineral load before the next droplet falls.

Fig. 85. A large diameter ring, Lapa do Bezerra, São Domingo karst area, Brazil. Photo by Ezio Rubbioli.

Fig. 86. A small diameter ring, Sorell Cave, Sardinia, Italy. Photo by Luco Montanaro.

The evolution of the much smaller rings in Sorell Cave is based on a different genetic mechanism (Fig. 87). In this case the rings are not generated by the splash of dripping in the center of the ring, but are caused by the separation of secondary droplets from main droplets on their fall from the ceiling to the floor. It was experimentally demonstated by Montanaro (1992) that if secondary droplets are formed at a distance of about 2 m from the tip of a stalactite, and if the direction of these secondary droplets slightly diverges from the vertical when detaching from the main droplet, then rings of a smaller diameter will develop. For the Sorell Cave rings, it was assumed (but not proved) that enlarged feeding channels (due to undersaturation) caused the detaching main droplets to separate into smaller droplets.

Other, quite unique, rings have been observed in the Blanca Navidad Hall area of Lechuguilla Cave (H. DuChene, pers. comm.). These rings are incised in gypsum rather than in mud or sand, and are composed of alteration crust-type calcite formed by a common-ion effect.

REFERENCES: Davis (1989e), Torres Capote et al. (1990; 1991), Meredith et al. (1992), Montanaro (1992), Auler (1993), Núñez Jiménez (1993).

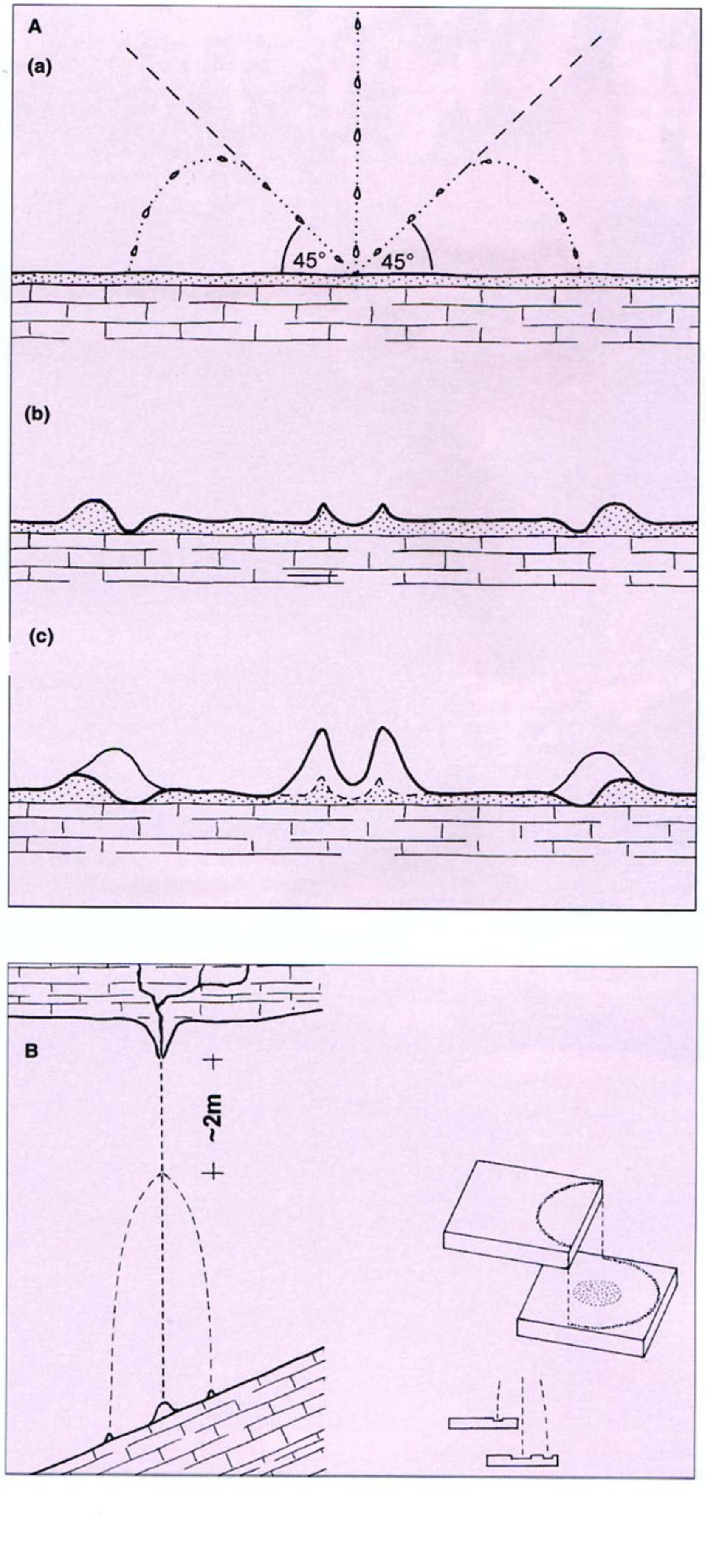

Fig. 87. Two mechanisms for the development of cave rings: (A) Large rings originate when water droplets falling onto a soft cave floor create secondary impact droplets which spray out in a circle from the central splash point. The farthest point reached by the secondary droplets is for those (a) starting at an angle of 45°. The impact of the secondary droplets creates a ring depression at a constant distance from the primary impact site (b). Calcite is deposited at the primary impact site (central splash point) as a small, hollow stalagmite and along the ring depression (c) by capillary water moving up along the side of the depression. (B) Small rings originate when secondary droplets separate from "oversized" drips about 2 m after they fall from the tips of stalactites (left side of drawing). Experimental proof for this mechanism was offered by Montanaro (1992) who obtained two half rings by placing two flat surfaces at different levels over the growing rings (right side of drawing).