Sand-Calcite Crystals from Garfield County, Utah

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By K. A. Sargent and H. D. Zeller

New occurrence of
sand-calcite crystals
found in the
Morrison Formation of
southern Utah

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Abstract

Sand-calcite crystals are found in the Morrison Formation of Jurassic age in south-central Garfield County, Utah. The outcrop area is less than 1 acre, yet the locality contains many fine specimens of single, double, and complex crystals in good hexagonal form. This is the first known occurrence of sand-calcite crystals in rocks of Jurassic age and is the first reported occurrence in Utah.

INTRODUCTION

Sand-calcite crystals are calcite crystals that include a large percentage of silt- to sand-size clastics. Many crystals, when removed from the enclosing matrix, exhibit well-developed scalenohedral forms. The locality reported here occurs on a ridge between two canyons that drain run-off from the Straight Cliffs in south-central Garfield County, Utah (fig. 1). The area of the deposit is somewhat less than 1 acre and is located in sec. 24, T. 36 S., R. 3 E. (fig. 2). It can be reached by an improved dirt road going south about 16 km from the town of Escalante and then by hiking about 1.5 km southeast from the road.

The crystals occur in a clean, white, poorly indurated sandstone of the Morrison Formation of Late Jurassic age (fig.3). The crystal-bearing zone is lens shaped and attains a maximum thickness of about 4.5 m. Crystal occurrence and quality vary both vertically and horizontally, and many crystals are concentrated along vertical zones. The abundance of crystals abruptly decreases both upward and downward from the lens-shaped zone. The base of the crystal zone is about 16 m above the base of the formation. The top of the formation is eroded at the crystal locality, but if the Morrison section were complete, the sand-calcite crystals would be about 36 m below the top of the formation (fig. 4). The crystals were probably formed by aqueous solutions charged with calcium carbonate that precipitated in the pore spaces around detrital sand grains. Crystal growth at nucleation centers of the calcium led to the formation of large calcite euhedra. Where several growth centers were close to each other, and where calcite euhedra grew simultaneously, the crystals formed penetration twins. It is not clear why this section of the Morrison Formation was the site for crystal growth, nor is it clear when the crystals formed. Sources of the calcium carbonate could be from some of the overlying calcareous beds in the Dakota Sandstone and Tropic Shale, both of Cretaceous age.

The locality was discovered in October of 1968 by H. D. Zeller of the U.S. Geological Survey and F. J. Alvey of Escalante, Utah. Zeller (1973) has published on the geology of the area.

This is the first known occurrence of sand-calcite crystals in Utah, and is the first reported occurrence in rocks of Jurassic age. Other reported localities are in rocks of Precambrian age (Weiblen, 1963), Triassic age (Fuhrman, 1968), and Late Permian age (Kadunas, 1967). The best known localities, which are famous for their beautifully formed crystals, are in beds of Tertiary age in South Dakota (Barbour, 1901) and in France (Lacroix, 1901).

Well-formed scalenohedron crystals such as are found here are rare in the United States, and it has been recommended to the Bureau of Land Management that the public land on which they occur be open to restricted collecting by permit only.

The authors wish to thank Donald M. Cheney for determining percent of insoluble material and obtaining specific-gravity values on four sand-calcite crystals. Dawn Reed did the photographic work on whole crystals, and Louise Hedricks did the photography of thin sections. The authors also thank Eugene E. Foord and Allen V. Heyl for checking the crystal forms.

MINERALOGY

Physical Character of the Crystals

The crystals weather out of the sandstone horizon in a variety of shapes and sizes. Many of those exposed to weathering are now ellipsoidal (fig. 5). Others still retain good hexagonal forms as single crystals (fig. 6), double interpenetration crystals or growth twins (fig. 7), and more complex compound crystals (fig. 8). Length ranges from about 2 cm for single crystals to as much as 30 cm for crystal clusters. The average crystal is 5 to 10 cm in length. Some weathered crystals show the relict bedding plane of the sandstone formation (fig. 9). Some rare forms show radiating patterns (rosettes) on broken surfaces (fig. 10).

Table 1. Modal analyses of sand-calcite crystals from Garfield County, Utah
[Values are in percent by volume]

Sample Number	Calcite matrix	Quartz	Chert and quartzite	Feldspar	Siltstone	Shale	Heavy minerals	Total
K–79–1	40.79	52.95	3.67	1.06	1.06	0.77	0.19	99.99
[1]K–79–2	35.98	57.22	3.78	.94	1.32	.76	.00	100.00
K–79–3	36.27	57.16	4.45	1.26	.29	.48	.09	100.00
K–79–4	37.83	54.90	4.73	1.75	.09	.70	.00	100.00

[1]Section cut normal to (0001). Other sections are without particular reference to crystallographic directions.

Petrography and Crystallography

Microscopic investigation showed the enclosed sand grains to be mostly quartz, chert, and quartzite with minor amounts of feldspar, siltstone, shale, and the heavy minerals—hornblende, pyroxene, biotite, zircon, magnetite-ilmenite, hematite, and garnet—in an optically continuous calcite matrix (fig. 11). Results of modal analyses of four thin sections of sand-calcite crystals are shown in table 1.

The detrital grains range in diameter from 0.1 to 0.7 mm, most are from 0.1 to 0.3 mm. Quartz and feldspar grains are mostly rounded to subrounded, whereas shale and especially chert tend to be subangular and elongate. Quartz and all other detrital grains are in random orientation. Composition planes between interpenetration and growth crystals are generally irregular (fig. 12).

The southern Utah sand-calcite crystals belong in the ditrigonal scalenohedral class of the hexagonal system (fig. 13). The forms appear nearly identical to, although slightly stubbier than, those described by Barbour (1901) from Devil Hill, S. Dak. As is true of all ditrigonal scalenohedrons, crystals rotated about the C-axis show similar scalene faces every 120°. For such crystals, careful measurement between scalene faces on four crystals shows angles that are less than 120° alternating with those that are greater than 120° (fig. 14). The crystals are scalenohedrons but, because of the sand inclusions, many of their faces are poorly developed, and the zigzag pattern (fig. 13) that connects lateral edges is difficult, though not impossible, to discern. Moreover, the faces do not lie in flat planes, but are slightly bowed both vertically and laterally (fig. 15) as are those described by Barbour (1901, p. 171). This bowing imparts to the crystals a distorted look, as if they had been given a right-hand, or clockwise, twist from the top of the C-axis while the bottom was held in place. All the scalenohedrons have rounded terminations, and probably are formed by the combination of one or more sets of rhombohedral planes (fig. 13B). No prismatic or pinacoidal faces are believed to exist on the Garfield County sand-calcite crystals.

Insoluble-Residue and Specific-Gravity Analyses

Analyses of the percent of insoluble material of four crystals were performed by D. M. Cheney of the U.S. Geological Survey.

Sample Number	Original weight	Crushed weight	Residue weight	Weight loss	Percent soluble material	Percent insoluble material
	grams					
1	38.57	38.54	26.54	12.00	31.1	68.9
2	27.03	27.01	18.46	8.55	31.7	68.3
3	31.00	30.95	20.98	9.98	32.2	67.8
4	38.70	38.54	26.44	12.10	31.4	68.6
Average					31.6	68.4

Weights were taken on the intact samples as a reference, but measured losses and percent loss were determined from the weight obtained after crushing. Samples were treated with an excess of 6N HCl, then washed, filtered, and dried.

Soluble calcite in the southern Utah crystals averages 31.6 percent by weight. This figure is lower than any other reported in the literature (table 2). The lower content of calcite in the Utah specimens may be due to the lower initial porosity of the fine to medium sand.

Dry bulk-density determinations on four bulk samples gave results ranging from 2.56 to 2.67 g/cm^3. Because of the wide variation in these values for crystals that otherwise appeared to be mineralogically consistent, other methods were used to narrow the range in specific-gravity determinations. Two samples were measured by the water displacement method, with results of 2.62 and 2.67 g/cm^3. The outer surface of the crystals, however, is porous, and two other samples were checked for specific gravity after being coated with a thin layer of paraffin (ρ=0.89), with results of 2.57 and 2.60 g/cm^3. These last values are low probably because the paraffin did not

Table 2. List of locations of sand-calcite crystals giving percent calcite, and age and name of enclosing beds

Location	Age and name of enclosing beds as reported	Soluble matter (in percent)	Source of data
Cholame Hills, Monterey County, Calif.	Early Miocene, Santa Margarita Formation.	35 (approx.)	Rogers and Reed (1926).
Devil Hill, S. Dak.	Miocene, Arikaree Formation	35.60 to 39.93 (36.19 ave)	Barbour (1901).
Rattlesnake Butte, S. Dak.	Early Miocene	36.95 to 37.00	Wanless (1922).
Goshen Hole, Wyo.	Miocene, Arikaree Formation	36.37 (crystal)	Barbour and Fisher (1902).
Do	Do	37.46 (concretion)	Do.
Bad Lands, Washington County, S. Dak.	Miocene, "White River sandstone."	40	Penfield and Ford (1900)
Fontainebleu, France.	Oligocene marls	37 to 50	Nichols (1906).
Mitchell region, Sioux County, Nebr.	Early Oligocene, Chadron Formation.	41.11	Barbour and Fisher (1901).
Stoneham, Colo.	Oligocene	41.4	Campbell and Mitchell (1961).
Salton, Calif.	Not reported, (probably Quaternary).	70.83 (concretion)	Nichols (1906).

saturate the sample all the way to the solid sand-calcite surface. Using modal values of 37.83 percent for calcite and 62.17 percent for silica sand, the calculated specific gravity of a sand-calcite crystal would be about 2.66 g/cm^3. By way of comparison, Nichols (1906) reported a range in specific gravity of sand-calcite crystals from 2.42 g/cm^3 (from Fontainebleau, France) to 2.69 g/cm^3 (concretions from Salton, Calif.). Specimens from Saratoga Springs, N.Y., were reported at 2.62 g/cm^3, and those from Devil Hill, S. Dak. at 2.64 g/cm^3 (Nichols, 1906).

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FIGURES 1–15

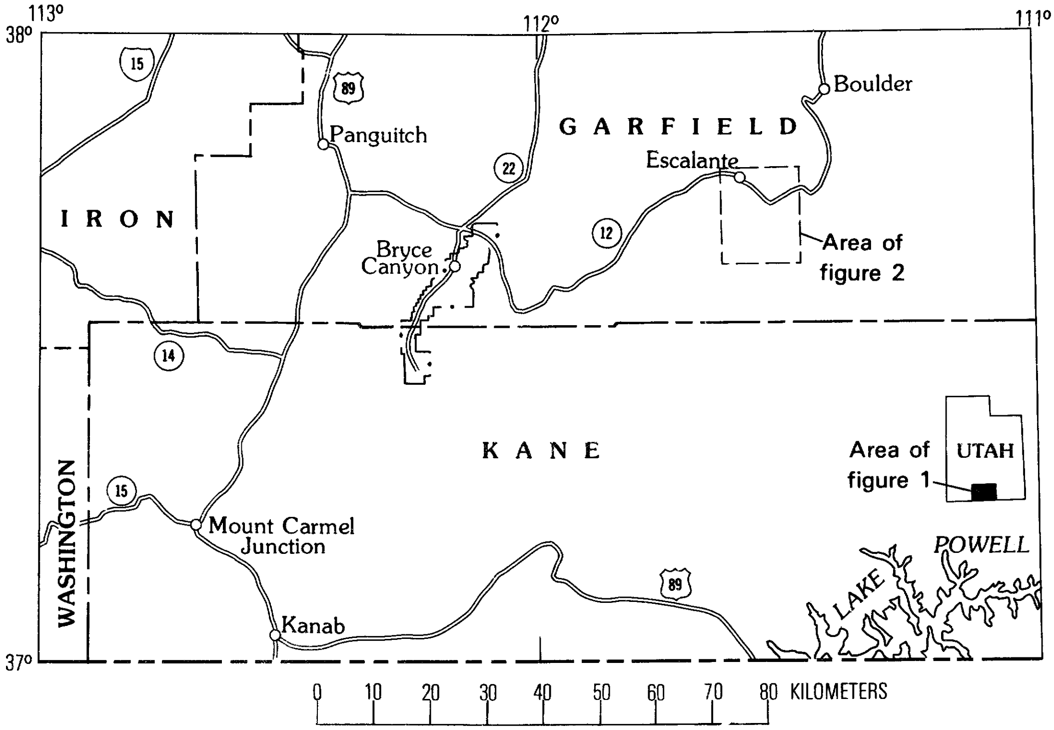

Figure 1. Index map of south-central Utah showing location of Escalante and area of figure 2.

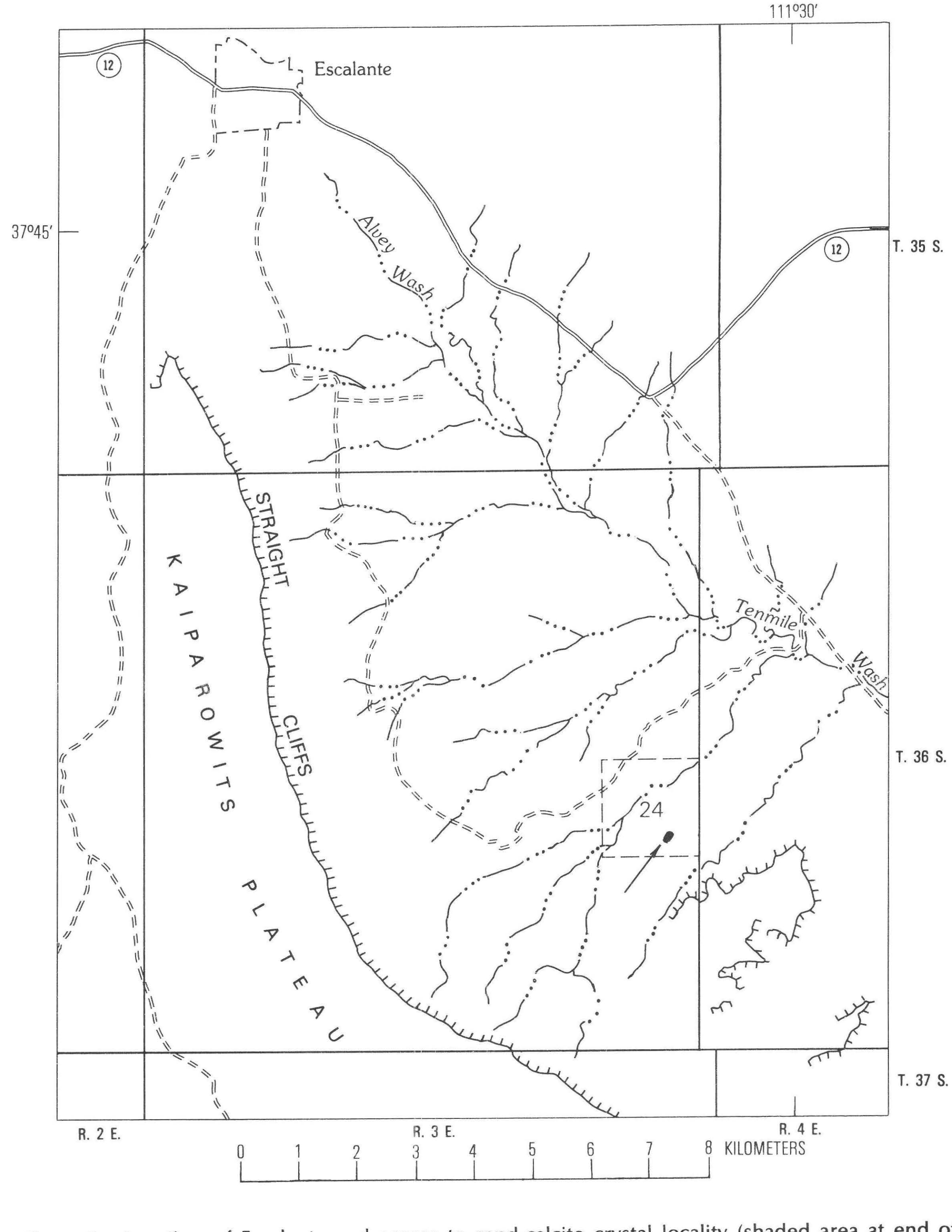

Figure 2. Location of Escalante and access to sand-calcite crystal locality (shaded area at end of arrow). Double dashes are improved dirt roads, solid lines are paved roads. Hachures are on cliff side of Kaiparowits Plateau and smaller mesas.

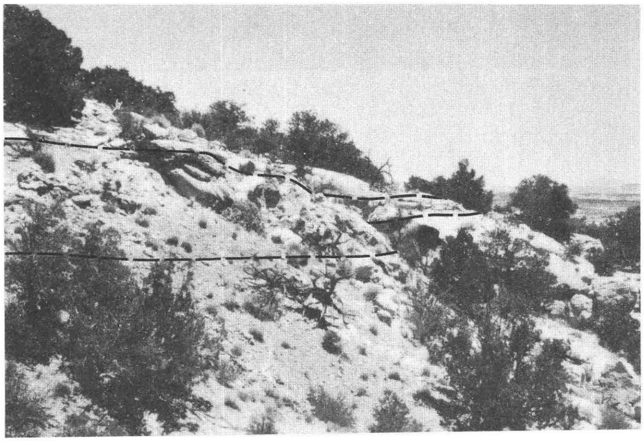

Figure 3. Sandstone horizon (within dashed boundaries) in Morrison Formation containing sand-calcite crystals. Looking east, Henry Mountains in distance at far right. Photograph by H. D. Zeller, June 1981.

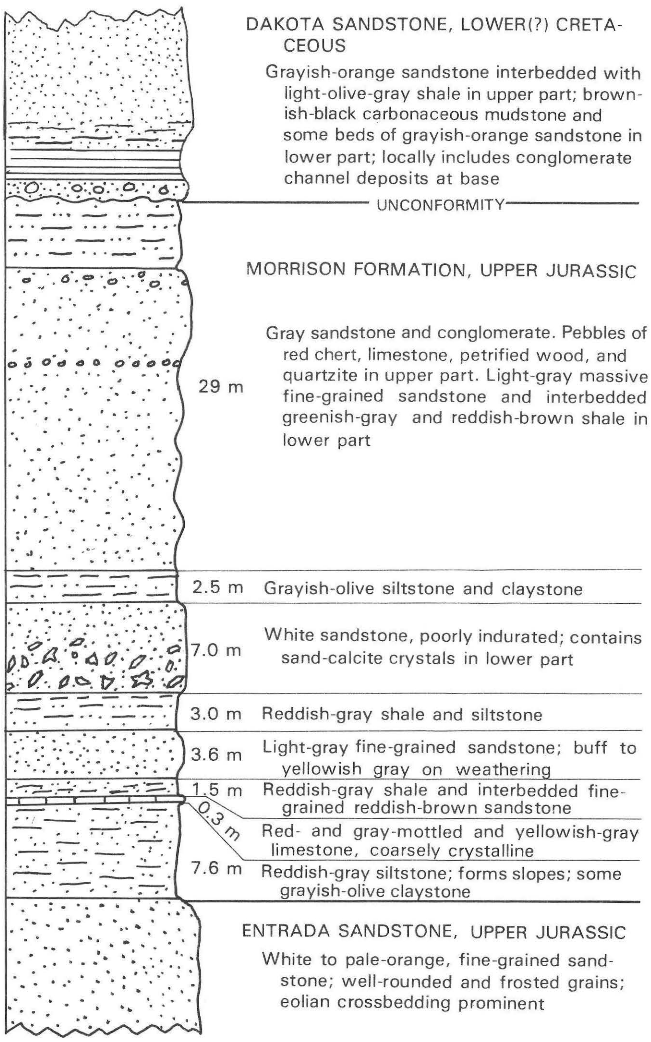

Figure 4. Stratigraphic section showing position of sand-calcite crystals in the Morrison Formation. Dakota Sandstone and uppermost Morrison Formation are not present at sand-calcite crystal locality.

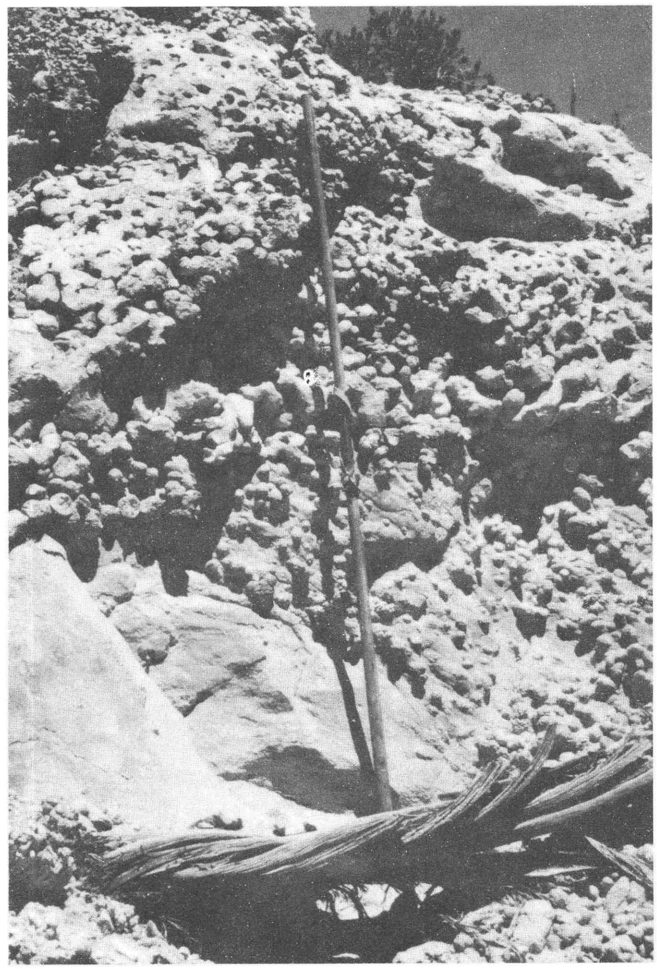

Figure 5. Outcrop face with sand-calcite crystals weathering to ellipsoidal shapes. Rod is 2 m long. Photograph by H. D. Zeller, June 1981.

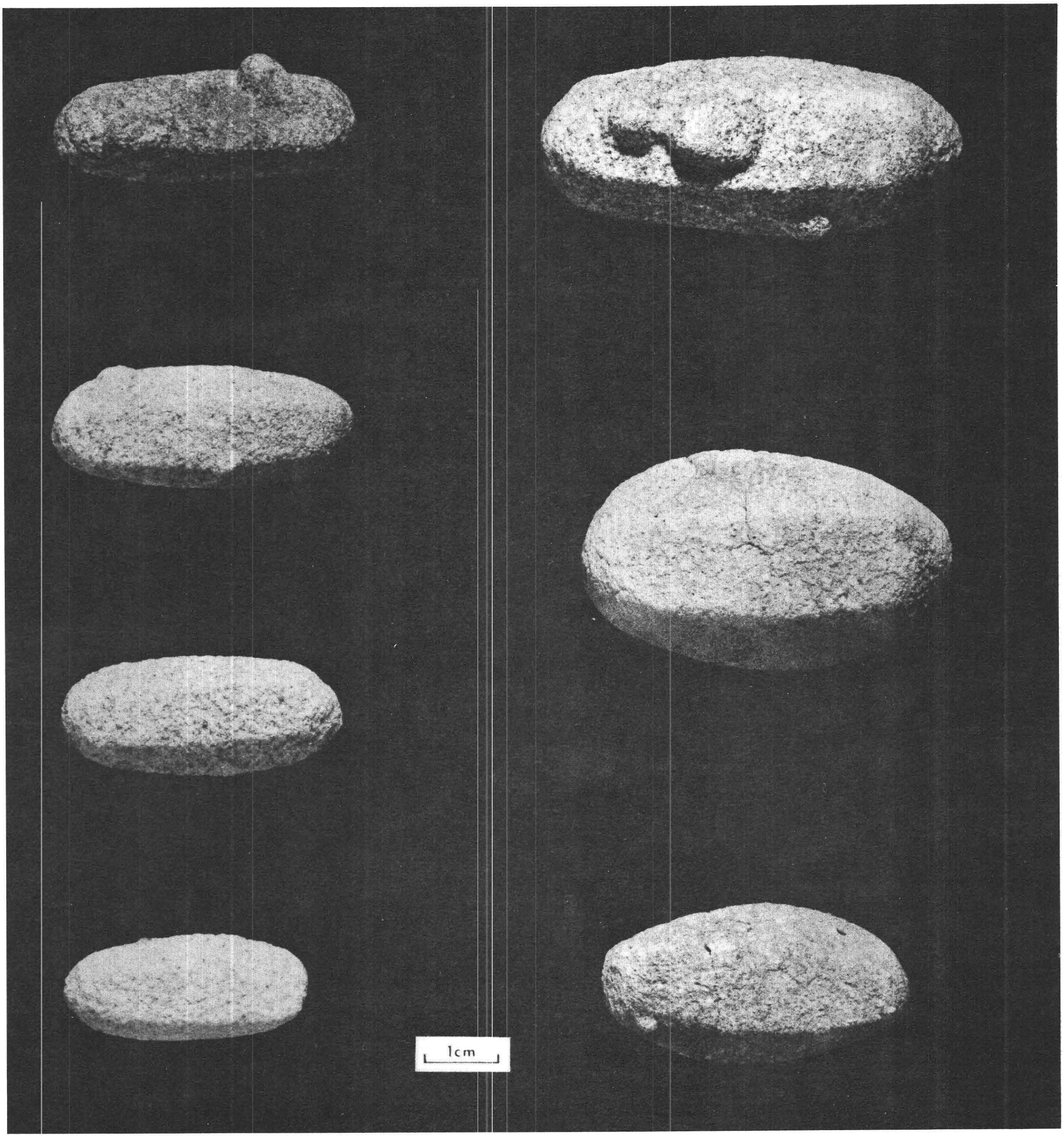

Figure 6. Single sand-calcite crystals showing typical shapes. Some show small penetration twins. Photograph by Dawn Reed, 1980.

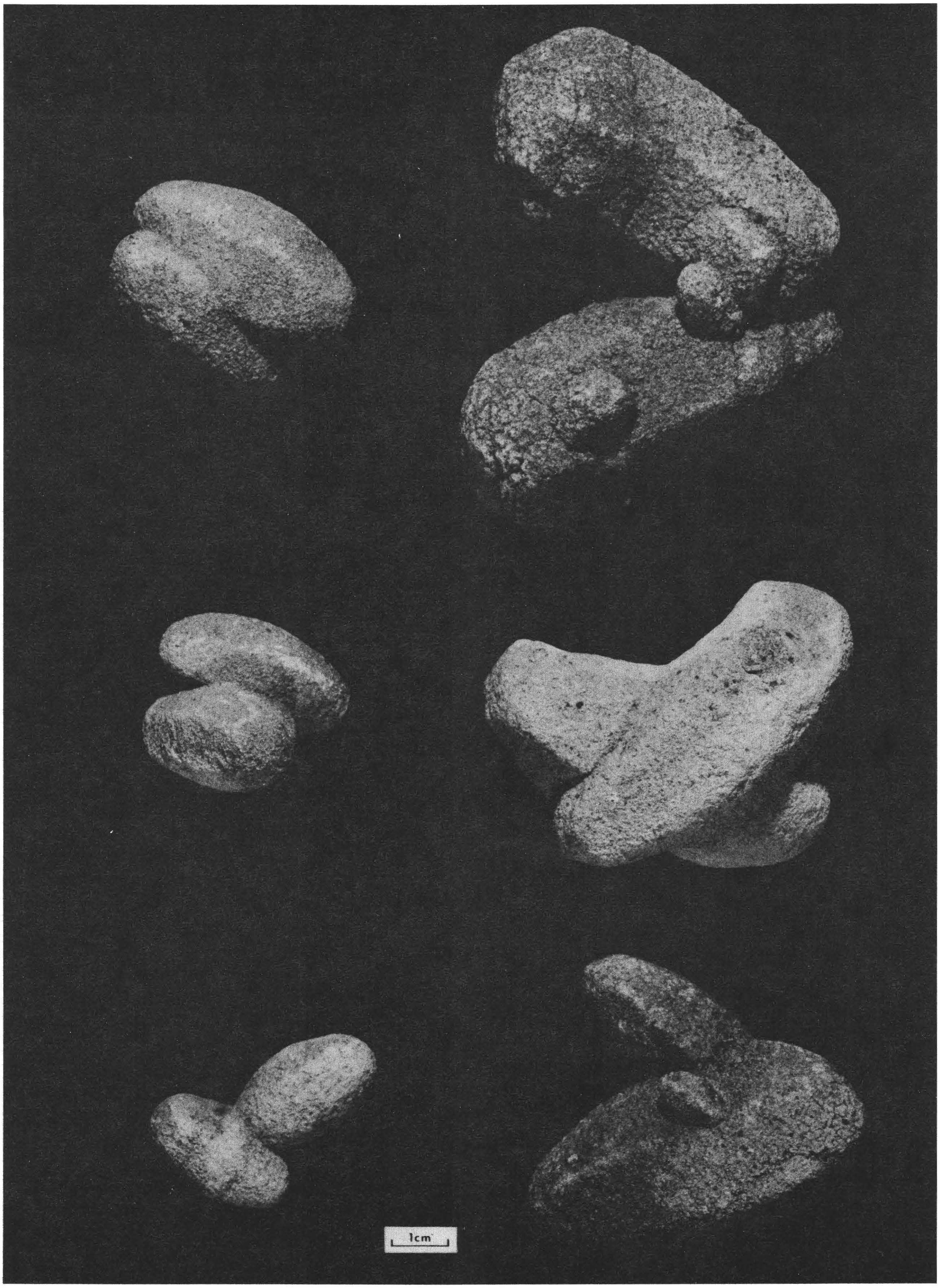

Figure 7. Double sand-calcite crystals showing varieties of interpenetration or growth twins. Photograph by Dawn Reed, 1980.

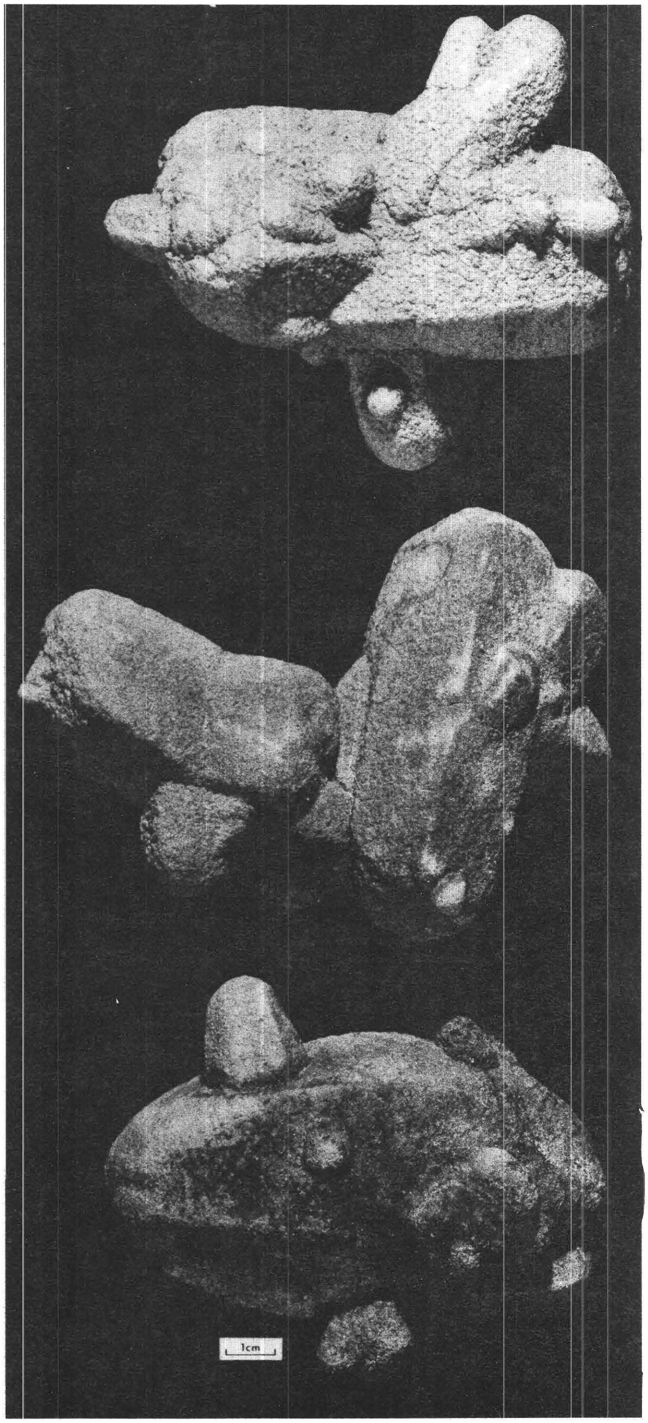

Figure 8. Sand-calcite crystals showing complex interpenetration or growth twins. In the center is a complex double crystal. Photograph by Dawn Reed, 1980.

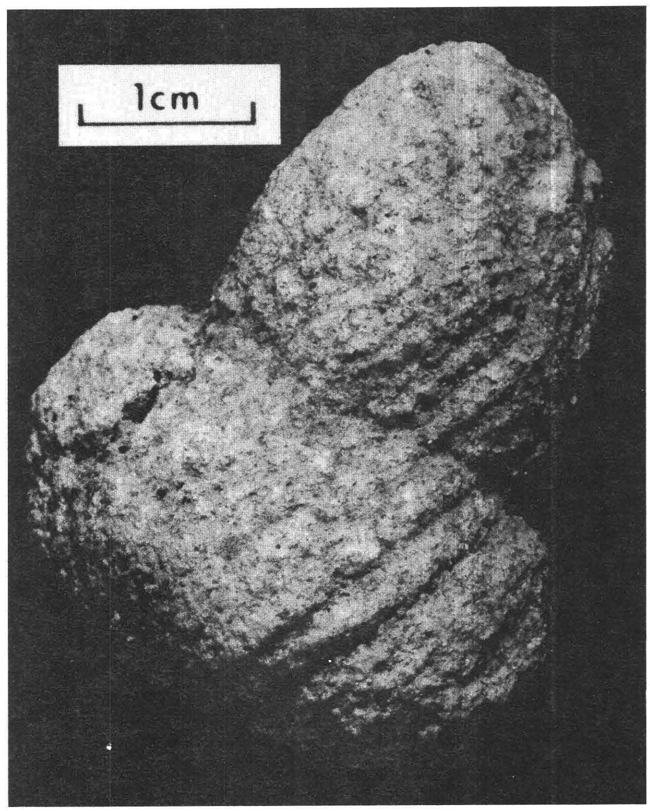

Figure 9. Sand-calcite growth twins showing relict bedding planes. Photograph by Dawn Reed, 1980.

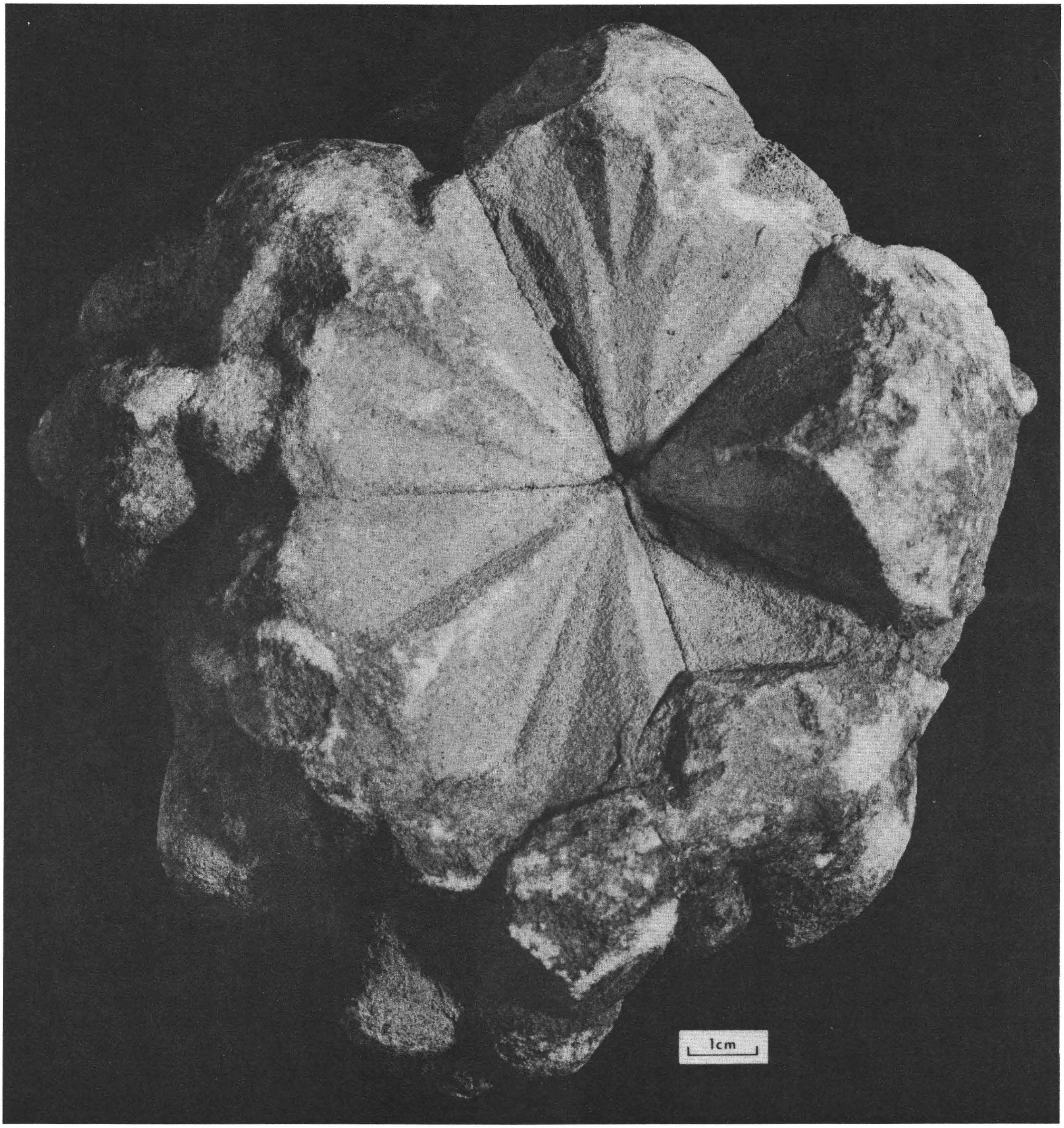

Figure 10. Broken complex sand-calcite crystal cluster (rosette) with radiating pattern. Photograph by Dawn Reed, 1980.

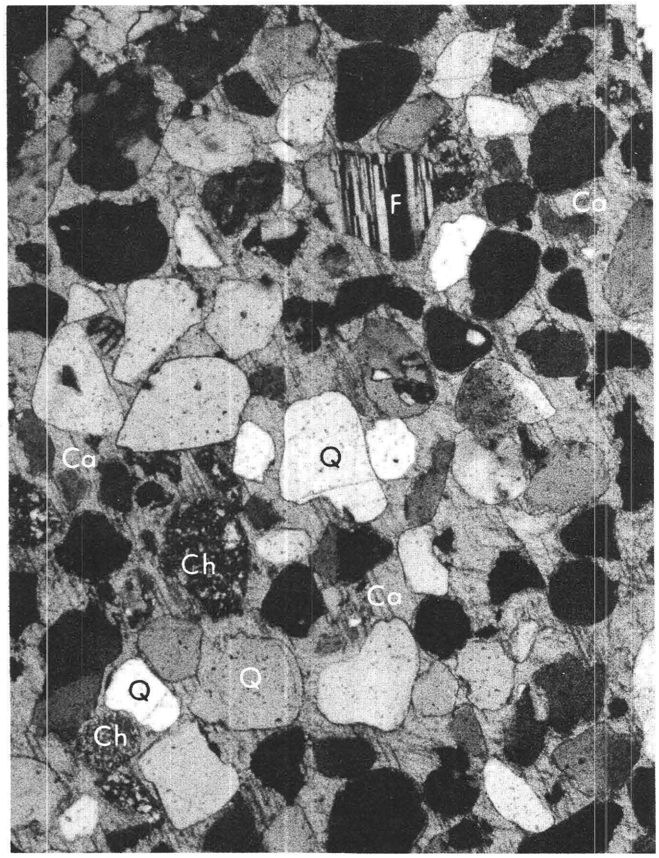

Figure 11. Photomicrograph of sand-calcite crystal showing rounded to subrounded detrital grains of quartz, Q, feldspar, F, and chert, Ch, in optically continuous matrix of calcite, Ca. Calcite shows one direction of cleavage. Crossed nicols, 50X magnification. Photograph by Louise Hedricks, 1980.

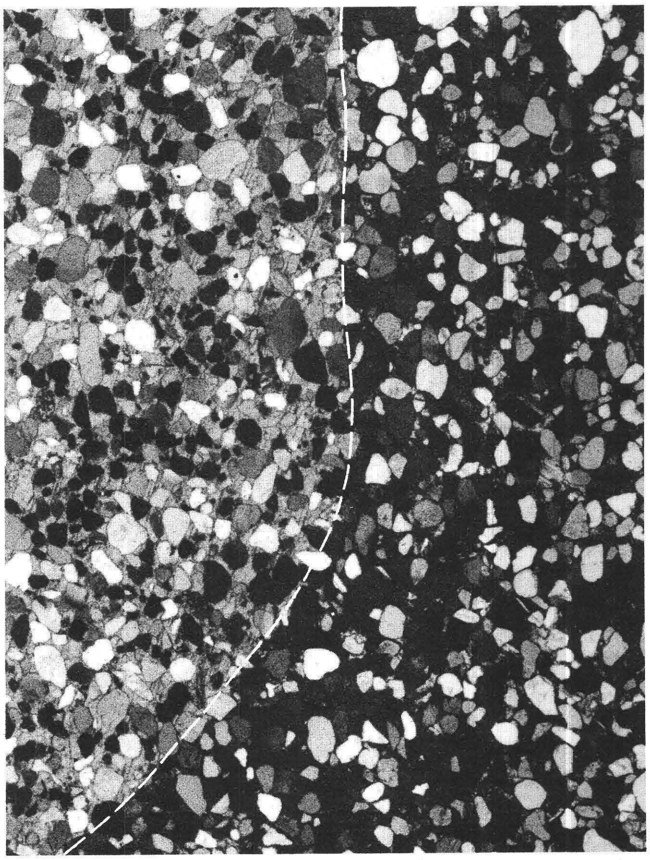

Figure 12. Photomicrograph of sand-calcite twin showing composition plane (dashed line) between penetration twins. Plane has irregular trace. Crossed nicols, 27X magnification. Photograph by Louise Hedricks, 1980.

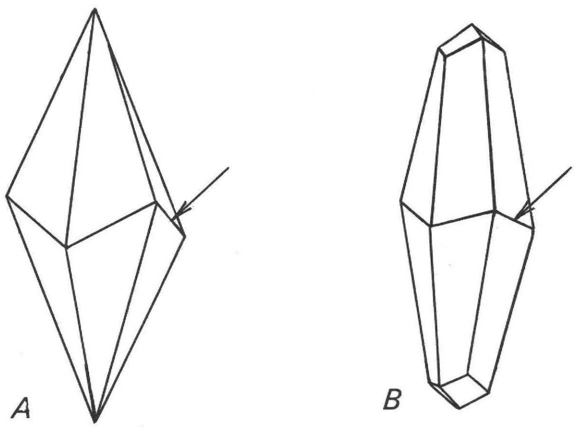

Figure 13. Line drawings of ditrigonal scalenhdrons. *A*, Idealized crystal having 12 similar scalene faces; *B*, Idealized crystal with rhombohedral terminations of scalene faces typical of sand-calcite crystals found in southern Utah. Note zigzag patterns at lateral edges (arrows) which are typical of this form.

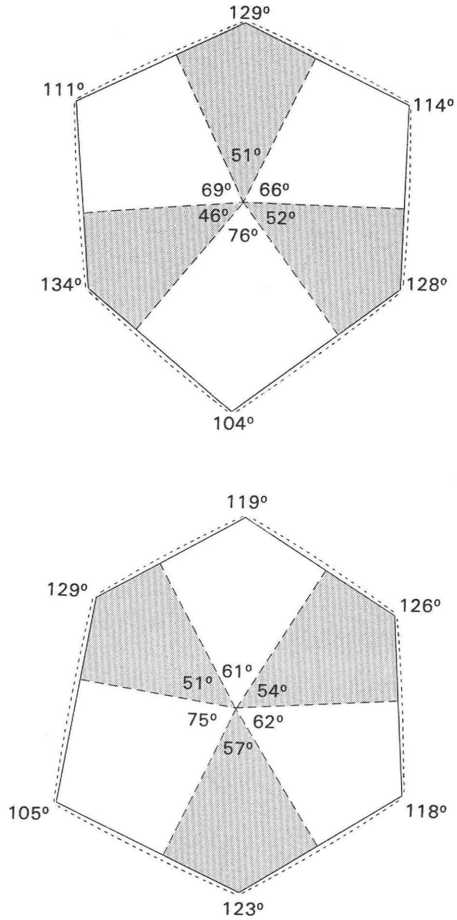

Figure 14. Diagram of two sand-calcite scalenohedrons showing angles measured in plane normal to C-axis (measurements are shown on outside edge of diagrams). As for all such crystals, angles of scalene faces greater than 120° (shaded) alternate with angles less than 120°. Angles shown near center of crystals are supplementary. Error in reading angles is generally about 2°. Because surfaces are curved (shown as dotted line), measurements must be made tangentially.

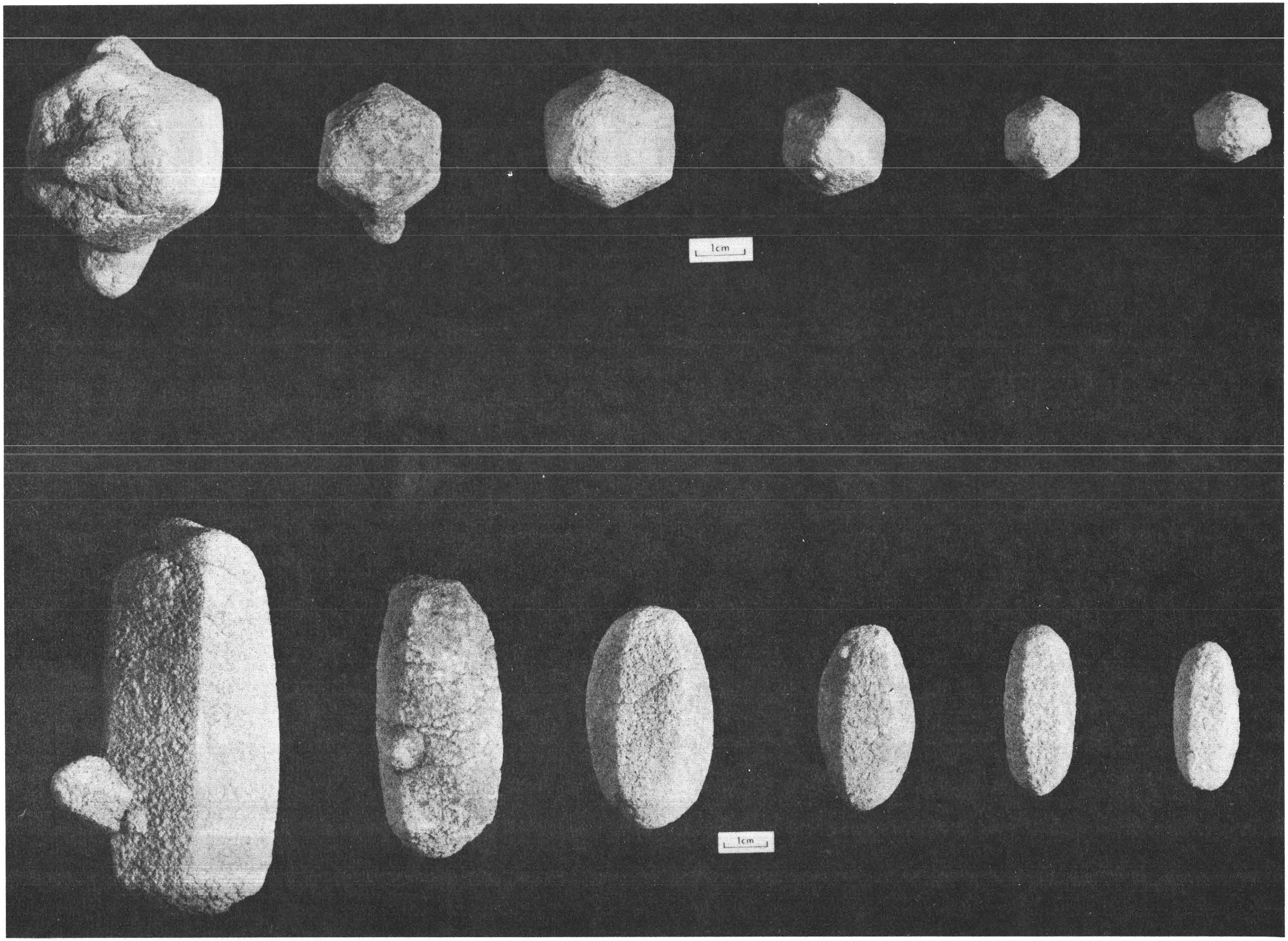

Figure 15. Sand-calcite crystals showing corresponding top and side views. Crystals show various degrees of curvature of scalene faces. Photograph by Dawn Reed, 1980.