THE AMERICAN MINERALOGIST, VOL. 50, SEPTEMBER, 1965

A SIMPLE METHOD FOR MAKING STEREOSCOPIC DRAWINGS

FRED ORDWAY,[1] *National Bureau of Standards, Washington, D. C.*

Stereoscopic drawings and photographs have long been used for display purposes (*e.g.*, von Laue and von Mises, 1926; Wells, 1954), but there has been no technique for rapid "stereoscopic sketching" to correspond with the rough sketching in orthographic or isometric projection, building of models, or sketching on an array of transparent sheets (Wyckoff and Ksanda, 1926), that most crystallographers do at some time during the course of a structure determination. Probably the reason is that each point in the two separate drawings must be plotted with considerable care to make a stereo pair that is even barely satisfactory. The derivation of the four coordinates needed to plot a point has been given by Bond (1947), together with an ingenious system for plotting to the required precision on a small scale.

Actually, however, the two drawings are identical except for a small horizontal displacement (parallax), which is a function of the distance of the point from the presumed observer. Thus a point can be plotted in one operation, by its vertical and horizontal coordinates alone, if the parallax displacement of one drawing relative to the other is properly adjusted.

The viewer's eye is easily strained by any significant vertical parallax, and the apparent distance of the point is a sensitive function of horizontal parallax. Thus the adjustment of parallax to change the apparent third coordinate must be made precisely. The only requirement to keep a portion of the drawing in a fixed plane when viewed stereoscopically is to make corresponding parts of the two views identical. This requirement can be met, even for the roughest sketch, by simple mechanical means such as marking with needle pricks or carbon paper.

The parallax adjustment can be made with any device providing a precisely calibrated, purely translational motion. Fortunately such devices are generally available in crystallographic laboratories, as instruments for measuring distances on *x*-ray films. The instrument I used was the Precession Film Measuring Device supplied by the Charles Supper Company. Other types could be used as well or, if they provide a larger drawing surface, perhaps better.

A sheet of plain paper and one of carbon paper (carbon face down) were taped to the glass film-viewing surface. Sheets of plain paper, carbon paper (face down), and graph paper (face up) were taped to the under side of the movable cursor bar. The movable sheets, with the plain paper

[1] Present address: Melpar, Inc., Falls Church, Virginia.

at the bottom, were in contact with the stationary sheet of carbon paper but moved with the cursor.

Each point was plotted by marking the graph paper according to the first two coordinates after adjusting the cursor to a setting proportional to the third coordinate. All points at the same level, and any desired identifying notes, can be marked at one setting. Different types of atoms were plotted as circles of different diameters, made with a fine ball-point pen and a draftsman's circle template. It was not necessary to avoid overlapping of marks for different levels so long as the lines were clear.

The two drawings were mounted together for viewing, a suitable set of points for alinement having been marked during the plotting procedure.

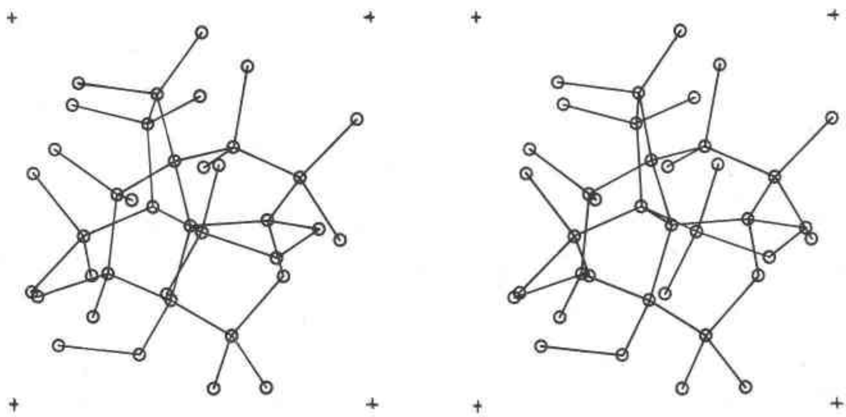

FIG. 1. A selected center, with its nearest, second, and third neighbors, in a noncrystalline tetrahedral network model (Ordway, 1964). After the centers were plotted, lines connecting them were drawn on the two views individually. This reproduction is one-half the original size, for viewing of the entire drawing without a stereoscope.

Interchange of the views inverts the apparent three-dimensional image, of course; the lower drawing should be viewed by the eye on that side toward which the cursor moves with increasing distance from the hypothetical observer.

For direct viewing, which is the most convenient way of using stereo pairs (Hughes, 1964), the width of the sketch must be kept below the interocular distance of about 6 cm. The proportions of the stereoscopic image depend upon a suitable choice of scale constant for the parallax adjustment. A total parallax range of about 1 cm is ample for drawings to be viewed at normal reading distance.

Larger sketches may be viewed with the conventional stereoscope, whose lenses have prism components to reduce the divergence, or with any of the various reflecting arrangements. By placing the carbon paper below one sheet of paper and above the other a reversed pair can be made for viewing with a single mirror.

Sketches made by this simple procedure (Fig. 1) suffer all the deficiencies of orthographic projections compared to perspective drawings, but proved very helpful in checking discrepancies in the coordinate data for a model network structure of 1144 atoms. Data for perspective projections, calculated as described by Bond (1947), may be plotted equally well by this method. If the parallax adjustment is graduated in terms of the third coordinage with a special scale (which may be non-linear to give a geometrically perfect stereo pair) the points can be plotted almost as rapidly in the three-dimensional sketch as on an ordinary map.

References

Bond, W. L. (1947) *Am. Mineral.* **32,** 454.
Hughes, R. D. (1964) *GeoTimes* **8** (6), 25.
Ordway, F. (1964) *Science* **143,** 800.
von Laue, M. and R. von Mises (1926) *Stereoskopbilder von Kristallgittern.* Julius Springer, Berlin.
Wells, A. F. (1954), *Acta Crystal.* **7,** 545.
Wyckoff, R. W. G. and C. J. Ksanda (1926) *Am. Jour. Sci.* **11,** 377–80.

THE AMERICAN MINERALOGIST, VOL. 50, SEPTEMBER, 1965

A NEW OCCURRENCE OF ANDORITE

Sidney A. Williams, *Silver King Mines, Inc.*

Andorite has been found in silver ores from the Taylor district near Ely, White Pine County, Nevada. The ores occur in brecciated limestones on either side of a fault zone and consist of sphalerite, galena, enargite, bournonite, tennantite, andorite and stibnite in varying proportions. Minor amounts of stephanite, miargyrite, and pyrostilpnite also occur. Gangue minerals are quartz, pyrite, fluorite and rare barite.

Andorite occurs as fine single crystals up to 6 mm in length in a vuggy silicified limestone. Most crystals are perched upon drusy quartz but some anhedra up to 12 mm across have been noted embedded in quartz. Measurement of several crystals on the two-circle goniometer revealed the following forms: b, {010}; u, {130}; k, {120}; l, {230}; m, {110}; o, {320}; W, {310}; X, {011}; γ {021}; y, {031}; r, {121}; and ϵ, {362}. The crystals are elongate on [001] and somewhat tabular on {100}. All {hkO} are present as striae with the exception of {230} and {120}. A typical crystal is illustrated in Fig. 1.

Stronger powder diffraction lines and estimated intensities (on a 1 to