features can be correctly identified more easily on the small stereoscopic prints than on the full-sized prints when viewed without a stereoscope. Should one be able to see stereoscopically without an instrument, the smaller prints are much more convenient in the field than those of contact size.

It would seem that this method of using stereoscopic vertical aerial photographs might also have important military uses. For example, a strip of overlapping photographs might be made of a road or similar feature, and the contact

FIG. 2. A stereoscopic pair after copying. Marginal glacial channels near Slaterville Springs, N. Y. (Photo by Agr. Adj. Adm.)

prints re-photographed in the way here described. Prints from the resulting negatives could be prepared easily and issued in any desired quantity to officers and others who might have occasion to conduct operations along that road and who might desire to have stereoscopic prints in the field in a form easily carried and easily used.

COLLEGE AND UNIVERSITY COURSES IN GEOLOGIC USES OF AERIAL PHOTOS, AND GENERAL DISCUSSION

THE following list of courses, although by no means complete, is believed to be representative both of the educational institutions offering such courses, and of the various ways in which the study of aerial photos is incorporated in the curriculum. Information about additional courses offered at other departments of geology and geography will be welcomed, and may be listed in a future issue of this JOURNAL.

INSTRUCTION IN USE OF AERIAL PHOTOS AT THE COLORADO SCHOOL OF MINES

See paper by Rooney and Levings on page 570 of this issue.

AERIAL PHOTOS IN THE GEOLOGIC PROGRAM AT KANSAS STATE COLLEGE. BY PROF. J. R. CHELIKOWSKY.

Instruction in the use of aerial photos is given in a course on Aerial Phototopography, which is required of all geology majors. The following courses are prerequisite: Field Methods, Physiography, Stratigraphic Geology, and Structural Geology. The course carries 3 credit hours, and has one hour of recitation and 6 hours of lab per week. The recitation is concerned with characteristics of photos, measurements on photos, and the use of photos in studying structure, stratigraphy, and landforms. The laboratory work is divided into 3 parts:

(1) Field work, consisting of structural, topographic, and geologic mapping with plane table and alidade, using enlarged photos as plane-table sheets, and making on-the-spot field identification of questionable photo detail.

(2) Construction of maps from field data, by: (a) tracing planimetric detail with the sketchmaster; (b) tracing geologic contacts and contours on an overlay under the stereoscope; and (c) use of section-line grids and radial-line plots in tracing photo detail to maps.

(3) Photogrammetric problems, including construction of a radial-line plot, laying of a controlled mosaic, and problems on parallax, relief, tilt, etc.

The following equipment is used: lens stereoscopes, mirror stereoscopes, and vertical sketchmasters.

PHOTO-INTERPRETATION AT LOUISIANA STATE UNIVERSITY. BY PROF. H. N. FISK.

Instruction in the use of aerial photos is given in Geography 120, for 2 semester hours credit, with one hour lecture and 2 hours of lab per week. This course uses both topographic maps and aerial photos, and the latter are studied with the stereoscope. Emphasis is on interpretation and recognition of structural features as shown by photographs. Prerequisites are Geology 1 and permission of the instructor. The course is not required.

I do not teach the above course but I have used aerial photographs and have definite opinions concerning their value to the geologist. This feeling may not be orthodox, judging from the many books written about the use of aerial photographs and their interpretation. These books appear to me to have the status of similar books written on "interpretation of topographic maps," and have no particular place as texts for courses in the curricula of geology departments. If the geologist desires to become a photogrammetric engineer or otherwise to study photographs with mechanical tools, then these books may have value to him but the course should be presented in engineering departments.

In my opinion the aerial photograph is one of the finest *tools* which has been presented to the geologist. However, the amount of geological information the geologist derives will be in direct proportion to his understanding of the science. Therefore, in the geological training of an individual, I see no need for a geological course in the use of aerial photographs but rather a need that the student study aerial photographs in connection with his study of other tools such as topograhpic, structural, and geological maps. Furthermore, I consider that all these tools should be utilized simultaneously while the student is taking basic courses in introductory geology, geomorphology, structural geology, and even stratigraphy. As you can see, my accent on the use of photographs is placed on the development of the individual's knowledge in the several geological fields. After this development he should be able to make geological interpretations from aerial photographs.

In my own courses, Gulf Coast Geology and Stratigraphy and Geology of North America, I am attempting to proceed along the above lines in my teach-

ing. We have a complete photographic coverage of southern U. S. so that it is easy to follow definite procedures in Gulf Coast Geology and in Stratigraphy (which is taught from the standpoint of environments and deposition). In the Geology of North America our coverage is limited; we do have a sufficient number of photographs, however, to emphasize the general aspects of the geology of the country.

COURSES IN USE OF PHOTOS AT MICHIGAN STATE COLLEGE. BY PROF. W. A. KELLY.

Three courses dealing with photos are given in the Department of Geology and Geography, and are entitled, respectively, "Aero-Photo Interpretation," "Photogrammetry," and "Aero-Geology." The first-mentioned of these is taught by Dr. Foster, who emphasizes features which are of particular interest to geographers. The other courses are taught by me.

The calendar prerequisites for the course in photogrammetry are few, but in practice few students enroll in the course without a year of college math, familiarity with maps (as a result of taking geology or geography courses), and field surveying. Very few engineering students ever take the course, although that division does not offer work in this field.

My objective in teaching the course is to give the student some conception of the uses to which he might put aerial photographs. I bear in mind that he is not likely to be a professional photogrammetrist, but rather one who may have numerous opportunities of using photographs in his own particular field, geology, forestry, etc. To my mind he is not going to be concerned with refined measurements, because he is not likely to be located with a company or institution which will have the facilities for such, nor is he likely to have the mathematical and physical background to deal with the microscopic difficulties which one might think, after casual perusal of many articles in our JOURNAL, are uppermost in the minds of all photogrammetrists.

I lecture one hour per week (11-week term) on the general topics of scale determination, relief distortion, tilt distortion, radial-line control, parallax, stereoscopy, relief determination, tri-metrogon photography, rectification of photographs, vertical and oblique.

The class also meets for 3 two-hour periods per week. During these periods they are given opportunity to practice and gain technique in the use of lens and mirror stereoscopes, Abrams contour finders, Fairchild stereocomparagraph, mechanical triangulators, sketchmasters (both vertical and oblique), rectoblique plotter, and Wallace & Tiernan altimeters. In addition, we contemplate the purchase of a multiscope. Our relations with the Abrams Corporation are cordial, and a visit to their plant is included. Through the courtesy of that company we are able to use some of their equipment. Our library includes about 10,000 aerial photos, anaglyphs, and a limited number of vectographs.

Projects completed in the field and laboratory include: obtaining horizontal and vertical control of an area for which we have aerial photos; rectification by templets; construction of tilt graph for a pair of photos; contouring by stereocomparator; profiles of areas with marked relief; planimetric maps from trimetrogon prints, and planimetric maps from oblique photos with ground control, both by the Canadian grid system and by division into triangles.

The course in Aero-geology is restricted to students of Junior standing, who have had "Photogrammetry," and at least one year of geology. The course emphasizes dimensional interpretation, as well as inferences on the basis of experience. In it I use photos of areas in which I have done field work, or for which there are adequate geologic map controls.

I believe that this field has considerable promise, and I would welcome a medium by which exchange of ideas could be made. We have many photos of areas that furnish good geologic problems, if only vertical control were obtainable. I have thought that, just as I could furnish control for Michigan areas, someone—in Texas, let us say—could do the same for photos from that state. Exchange of letters between geologists who teach photogrammetry should prove advantageous.

AERIAL PHOTOS IN THE GEOLOGY DEPARTMENT AT NORTHWESTERN UNIVERSITY. BY PROF. W. C. KRUMBEIN.

Our course in the interpretation of aerial photographs is slanted towards its engineering applications and is taught by us mainly to engineering students. The catalog description of this course is as follows:

> C6. Geology from Aerial Photographs. Winter quarter (3 hours). Interpretation from aerial photographs of drainage patterns, water supply and hydrology, and the nature and distribution of rocks and soils. Stress is laid on the quantitative approach and on engineering applications. Prerequisites: Engineering geology or historical geology and analytic geometry.

This course is offered in a special laboratory which is equipped with about 20 mirror stereoscopes and an equal number of magnifying stereoscopes, 2 vertical sketchmasters, 4 Abrams contour finders, and other material. We have county index sheets covering substantial blocks of the United States, as well as total county coverage of aerial photographs in a number of selected areas. Although the course is offered mainly for engineers, our own students are displaying an increasing interest, so that we shall probably expand the course content to include more strictly geological problems. At present the course is required for certain students in civil engineering. It is taught by Prof. Dapples and me, and we feel that it is successful.

THE USE OF AERIAL PHOTOS IN GEOLOGY AT OHIO STATE UNIVERSITY. CHARLES H. SUMERSON, ASSISTANT PROFESSOR OF GEOLOGY.

The Department of Geology at Ohio State University is very much interested in photogrammetry as an assisting technique in teaching geology and an important tool for the professional geologist in carrying out field studies. We are not interested in turning out photogrammetrists, but geologists who are as familiar with the principles of photogrammetry as with those of plane table mapping and surveying.

Our use of aerial photos is best explained by a summary of some of the courses in the geology curriculum: We do not now use them in the elementary sections, which are cultural in design. The initial work is given in a course on interpretation of topographic maps and aerial photographs (one quarter, three hours), where the elementary geometry of a photograph is taught, and the use of the stereoscope, scale, interpretation of planimetry, comparison of photos to topographic maps, and recognition of general features and culture. The next course (one quarter, three hours) concentrates on geologic maps; aerial photos are used in close association with them, emphasis being placed on identifying and tracing formations and on interpretation of structure.

Up to this point the work with aerial photographs is chiefly interpretation. Then follows a course in geologic surveying (one quarter, three hours), in which standard methods for carrying on geologic field work are taught, and the use of aerial photos in field work is begun. Principles of triangulation and radial line plotting for planimetry are discussed. The undergraduate's training culminates in a summer field course (fifteen hours) at the University's geology field camp

in Ephraim, Utah. There the student works out the geology of an area on a professional basis, using the plane table and aerial photos. With his own control he constructs a planimetric map by radial line plotting, on which he projects the geology. The stereoscope and sketchmaster are used in this work.

Graduate students who select problems of an areal nature in areas which are unmapped face the necessity of constructing their own base maps. For this purpose training is offered in the use of the less complex photogrammetric instruments, such as the Kail plotter and the stereocomparagraph. This is the most advanced formal instruction in photogrammetry which is given at Ohio State.

Besides training the student in the use of aerial photos, the teacher finds the photos themselves of great value as illustrative and problem material for many other geology courses. It is the intention of our department to build up a series of work sets of photos for such courses as geomorphology and structural geology. Their use in the field of engineering geology has yet to be explored, but there are numerous examples available illustrating the application of geological knowledge to engineering problems.

In pursuit of this program we are making a library file of photos of various geologic features and structures in the United States and foreign areas. This will include not only the features ordinarily associated with geology, but also such subjects as oil fields (for location and spacing of wells, and extent of producing areas), mining (especially open pit, where problems of production can be seen in stereoscopic view), and engineering (for training in consultation work in varied types of projects such as dam construction, highway location, flood control and irrigation). Such a collection will be valuable in bringing into the classroom and laboratory a three-dimension concept of examples discussed.

The program outlined here is just getting under way. It is part of the newly-organized geology curriculum at Ohio State University, the aim of which is to turn out good geologists with well-rounded backgrounds in all techniques that are of aid in geologic work.

TRAINING IN GEOLOGIC USE OF AERIAL PHOTOS AT PRINCETON UNIVERSITY. BY PROF. PAUL MACCLINTOCK.

We are starting a one-semester course on "Terrain Interpretation," which is the recognition and genetic interpretation of terrain features as shown on topographic maps and air-photos. The course also includes the elements of plane table surveying and of photogrammetry. It is a 3-credit course involving one lecture and 2 two-hour labs per week for 16 weeks. It is an elective course with introductory geology prerequisite.

The equipment consists of plane tables and alidades for surveying, and of simple pocket stereoscopes for air-photos. It has been found successful to make stereograms of type land forms and have the class learn to interpret air-photo terrain by means of these types. The students pass to regional interpretation without any difficulty. We have enough prints of each stereogram made so that the whole class can study the same thing at the same time. In this way the teaching and supervision problems are greatly reduced, as well as the great expense of equipping a laboratory with enough stereo pairs for 20 men to cover the wide variety of land forms which are needed.

We feel that this course offers the chance for excellent training in geological thinking as well as the introduction to a technique of field work which is of great importance to the geologist. Care must be exercised, however, not to belabor the obvious in the geologic interpretation of the photos, nor to be dogmatic when the evidence is insufficient, but rather to teach what can and what cannot be inferred.

PHOTO-GEOLOGY AT THE UNIVERSITY OF CALIFORNIA, LOS ANGELES. BY PROF. WILLIAM C. PUTMAN.

No course by itself in the use of aerial photographs is taught in the Geology Department at UCLA. Aerial photographs are used rather extensively in three courses as part of the regular program. One of these is a course in Geomorphology, and photographs are used in the laboratory along with topographic maps as a basis for interpreting landforms. The other two are field courses; one is run on Saturdays during the regular term, the other is held for six weeks during the summer. Aerial photographs are used in both these courses as a base for geologic mapping.

A course in aerial photographs would be desirable, but our list of required courses is now so long that we hesitate to add any additional burden. The best thing, in view of the large number of university and departmental requirements, is to make the use and interpretation of aerial photographs an integral part of existing courses.

Were such a course to be given, I should imagine that it would be best suited to upper division students, give about 3 hours credit, have a prerequisite of a beginning course in geology, and be an elective. I favor very much the idea of making such a course open to agriculture, forestry and engineering students.

USE OF AERIAL PHOTOS IN GEOLOGY AT THE UNIVERSITY OF CINCINNATI. BY PROF. JOHN L. RICH.

One course dealing directly with aerial photos is given; the catalog description is as follows:

> 30b. (3) Interpretation of Aerial Photographs.—Lectures and laboratory. Hours to be arranged. . . . The geologic and geographic interpretation of aerial photographs, and their use in mapping. Prerequisite: Course 1 or equivalent. Mr. Rich.

The course carries 3 credits and is given in the second semester of alternate years. In the lectures I spend most of the time showing lantern slides of aerial photographs of various geological features and types of topography, and try to correlate the latter with bedrock and structure; students are quizzed orally on the slides also. Coordinate with the lectures I give, largely as homework, the elementary principles of photogrammetry, particularly as applied to map-making by simple methods which can be carried out without elaborate equipment. In the laboratory we practice map-making from aerial photographs and from ground photographs. We give practice in the use of the radial-line method, and the Canadian grid method, and devote considerable attention to oblique photographs and oblique perspective. The students also have practice in interpreting geology and structure under the stereoscope.

For equipment we have one Abrams Contour Finder, sufficient Abrams lens stereoscopes for each member of the class, 3 universal adjustment mirror stereoscopes of the type designed by the U. S. Geological Survey, one Austin photo-interpretometer, and a set of parallax wedges prepared by the U. S. Forest Service. We also have a considerable collection of aerial photographs including both verticals and trimetrogon sets.

In elementary geology, I make constant use of lantern slides of aerial photographs in my lectures, and use stereoscopic prints extensively in the laboratory. For the latter, we use prints prepared according to the method described elsewhere in this issue, and these are viewed with simple lens stereoscopes.

PHOTO-GEOLOGY AT THE UNIVERSITY OF KANSAS. BY PROF H. T. U. SMITH.

Course work in photo-geology has been an integral part of the geologic curriculum at the University of Kansas since 1939. Since that time there has been a gradual evolution of the basic course, reflecting both the growing needs of professional geologists and the rapid advances in the science itself. At present, the basic course, Geology 216, Photogrammetry and Photogeology, is a one-semester course for three hours credit, open to seniors and graduate students. Photogrammetric methods for studying photos and preparing planimetric and contour maps from both vertical and oblique photos occupy about two-thirds of the time, and the interpretation and mapping of geologic and geomorphic features the remaining third. Throughout the course, the emphasis is on laboratory work. In that part dealing with photogeology, the aim is twofold: first, to give the student a broad acquaintance with a wide range of geologic features from many parts of the earth's surface, and, second, to give specific practice in the detailed study and mapping of one selected area.

The following instrumental equipment is available for class work: K-20 aerial camera, lens and mirror stereoscopes, vertical sketchmasters, universal sketchmaster, mechanical triangulators, Fairchild templet slotter and accessories, Kail radial-line plotter, contour finder and stereocomparagraph, and rectoblique plotter. In addition, it is planned to obtain a multiscope and a Mahan contour plotter in the near future. A photographic dark room is available to students. The photo collection, which provides the basis for all strictly geologic study and reference, consists of several thousand carefully selected mosaics and vertical and oblique prints from all parts of the world. This collection is being added to constantly.

Paralleling the basic course for geologists, described above, is a similar course for majors in the department of Geography. The treatment of photogrammetric pinciples and procedures is the same in both courses, but the part devoted to photo interpretation concentrates on landforms and cultural features of particular interest to geographers.

A course in Advanced Photogrammetry and Photogeology is now being planned, and is intended to provide supplementary instruction in the use of more precise methods of contouring, Trimetrogon mapping, and other mapping techniques, together with the interpretation and mapping of more difficult geology.

In addition to these specific courses, aerial photos are used also in other standard geology courses. In Structural Geology, lantern slides of photos showing typical structures are used to illustrate lectures. In the mapping course given at the summer field camp, photos are used in part as a basis for field mapping. In Geomorphology, stereoscopic study of aerial photos is used for the laboratory analysis of landforms. In graduate research courses, devoted to the study of special problems, such as those for the master's and doctor's theses, aerial photos are used extensively for preliminary laboratory study, for field mapping, and for the final map compilation.

AERIAL PHOTOS IN THE STUDY OF GEOLOGY AT THE UNIVERSITY OF MICHIGAN. BY PROF. A. J. EARDLEY.

In my course, "Interpretation of Geologic Maps and Aerial Photographs," I start the students out with a strip of about 7 photos, on the first of which I have indicated the position of the formational contacts. There are about 8 formations, which trend at an acute angle across the strip. The relief is strong. The student is supposed to trace out the contacts under the stereoscope. After I check and

approve his contacts, he makes a simple compilation with the radial line method on an acetate sheet and produces his first geologic map. This takes about three weeks in a 3-hour, one-semester course. Then I go to the geologic maps for about 10 weeks, then back to aerial photos and their geologic applications for the last 3 weeks of the semester.

INSTRUCTION IN GEOLOGIC USES OF AERIAL PHOTOS AT THE UNIVERSITY OF NEW MEXICO. BY PROF. SHERMAN WENGERD.

A course in Geologic Interpretation of Aerial Photographs is to be offered starting in the first part of next year. The catalog description is as follows:

> Geologic Interpretation of Aerial Photographs. An introduction to characteristics of the aerial photograph, basic map projections, elementary photogrammetric compilations, and stereoscopy. Preparation of simple contour maps and aerial mosaics. Interpretation of geographic and geologic features, and field identifications. Areal geologic mapping from oblique and vertical photographs. Prerequisites: Geology 1 and 2, Math. 16 (plane trigonometry) Engineering 1L and 2L (elementary surveying). Two-hour course, one lecture hour and one three-hour lab.

The above course is for sophomores and juniors majoring in geology. We also plan to give an advanced 3-hour course for seniors and graduate students only; the title probably will be: Aerial Photogrammetry and Aero-geology.

GEOLOGIC USES OF PHOTOS AT THE UNIVERSITY OF OKLAHOMA.

A course devoted almost entirely to the geologic interpretation of aerial photos is offered by Prof. F. A. Melton for seniors and graduate students in geology. An unusually large collection of photos is available for study.

PHOTO-INTERPRETATION AT THE UNIVERSITY OF WISCONSIN. (INFORMATION FROM PROF. KIRK STONE.)

A course in Air Photo Interpretation is given in the Department of Geography by Prof. Kirk Stone. It is a one-semester course carrying 3 credits. The following topics are included: stereoscopy, characteristics of photos, interpretation of physical features (relief, drainage, vegetation, etc.), and interpretation of cultural features (transportation facilities, rural land use, urban land use, etc). Laboratory study is supplemented by field work.

AERIAL PHOTOS IN GEOLOGY COURSES AT WELLESLEY COLLEGE. BY PROF. LOUISE KINGSLEY.

We use aerial photos in several courses but have no course which is exclusively devoted to such work. In the elementary course (one year, 6 semester hours), photos are used in introducing contour maps and are included in several exercises in map interpretation. Professor Dowse also uses photos in her course on cartography, supplementing other work with them during most of the semester, and using them exclusively for about 4 weeks. I use a few photos in structural geology and Professor Dowse does the same in geomorphology. Twice we have had students work on special projects in which they made geologic maps from photos.