THE USES OF AERIAL PHOTOGRAMMETRY IN THE PETROLEUM INDUSTRY*

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General

IN MAKING reference to the part science has played in the development of the petroleum industry, it would be well to give some recognition to the part the petroleum industry has played in the development of science. It is a well-known fact that this industry has, directly or indirectly, contributed considerably more to scientific developments than any other industry. The products of these developments are so far reaching into our everyday life that we fail to notice just why such things have come about but practically every phase of our high standards of living can be traced to the co-relationship of science and the petroleum industry.

Due to the overlapping of the various sciences used in this industry, it is difficult to isolate any particular one science as a separate functioning unit to the exclusion of others, but I shall attempt to isolate as far as practical that part in this development that can be accredited to the science of "Aerial Photogrammetry."

The Purpose of Maps

The first and most important step in solving any problem is to assemble all the facts of the case. A set of plans or a map should show all the facts or conditions pertaining to a particular problem, but only a photograph is capable of showing instantaneously a true representation of all visible facts.

The first step in practically every engineering enterprise is to make plans or a map to represent the facts or conditions that will be encountered in its development. Due to the magnitude of the areas covered by the operations of the petroleum industry, the preparation of maps becomes a major factor in the development.

Old Methods of Mapping

In the early stages of the petroleum industry, the mapping work was not considered of such prime importance as the operations were more or less localized, but as the operations expanded, the need for extensive map information was recognized.

The best representation of an area or county at that time was a compilation of accurate protractions of the field notes of each survey, with the land subdivision and individual tracts platted in such surveys, according to the best interpretation or description available in the county or parish records.

The knowledge that this method of map compilation was far from furnishing a true representation was evident, even in the initial correlation of the surveys, as there would always be some places where the notes would conflict with each other and the analysis of the case would be nothing more than a guess. Of course, an actual survey on the ground would solve the problem, but such surveys are too expensive for the purpose of general map work.

The government topographic and planimetric quadrangle sheets of Texas cover only a few small areas, and the use of this information, to adjust the basic surveys of ownership maps, is seldom used.

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The Advent of Aerial Photogrammetry

Photographic information was used in mapping many years prior to the advent of aerial photography and the mosaic assembly. The Exploration Department of Shell was a pioneer in the use of oblique photographs, taken from high mountain points, for reconnaissance mapping.

Aerial photography, as a mapping medium, was first used extensively by the Army in the World War. After the war, the Army Photo Sections worked in conjunction with other government agencies on various mapping projects.

As the value of this type of map information was proved, several private companies were formed to promote and develop this new science as a commercial enterprise.

Due to the fact that the greatest potential market for aerial survey information at that time was the petroleum industry, the promotion of the enterprise was economically contingent or dependent on the reception or backing the major oil companies would give to such a service.

A short visit to the engineering departments of the several major oil companies will prove by the volume of aerial photo grids that the petroleum industry has sponsored and accepted the new science of "Aerial Photogrammetry." No one will dispute the fact that a "new era" of mapping progress was ushered in with the advent of aerial photogrammetry. Comparing the quality of mosaic grids, of the initial work, and its subsequent uses with the work of today, will show that the advancement in this science is developing at a very satisfactory rate. This fact should stimulate our utmost co-operation in all future developments.

The development of uses for aerial photos in the petroleum industry has been as rapid as the methods of application will permit and this past decade has witnessed an entire transformation of processes in the map making and field survey work.

The Use of Aerial Photos in Cadastral Surveys

The value of an aerial photo grid to the chief of the field survey party is contingent entirely on local conditions. The accessibility and general conditions of any area can be determined from the photos before moving in, and much time can be saved by planning the procedure of the work according to these data.

In South Louisiana where most areas are composed to a major degree of sea marsh and waterways, the use of the photo grids is indispensable and, outside of the marsh buggy, is considered the most useful accessory to the work.

To those of you not familiar with conditions in South Louisiana, the "marsh buggy" is a revamped auto-chassis mounted on large, wide "slat type wheels". This vehicle provides transportation over soft marshes that are impassable to everything else, except airplanes.

Where the original corners and reference marks have been obliterated, as is the case in most every area, the correlation of the surveys to the physical evidence on the photos, such as ties to streams, lake and bayou meanders, etc., furnishes a basic retracement on which very little adjustment is necessary to satisfy the condition called for in the field notes.

After the area is controlled by traverse, the photo grid is adjusted and all the general culture, not directly pertaining to the original survey, is transferred to the survey hard copy plat. There is no doubt about the completeness of the survey when the ground information is incorporated with the picture evidence on these plats.

One of the main purposes of a field survey is to re-establish the original survey lines from which emanated the title to the subdivisions or tracts enclosed by such lines. The location of the original lines is seldom found to be laid out on the ground according to the recorded field or patent notes. The bearings of the lines are sometimes off several degrees and the lengths nearly always are in excess of the calls.

The original corners of an old survey placed on the ground, sometimes dating back over a hundred years, are rarely recovered and the re-establishment of the lines must be by the accessory calls for mounds, trees, streams or physical evidence. While the trees and general clues of demarkation are strictly a job that can only be accomplished on the ground, much of this evidence, such as the tracement of an old stream channel, as it existed a hundred years ago, can be determined only from the aerial photograph. The birdseye view of the color changes and shadows on the photographs will reveal the progressive steps of the changes in the stream channel, where a man on the ground would never find such correlation evidence.

While the present fence lines, roads, corners of later surveys, etc., must be tied in for evidence, the location of the present claim lines, or lines of occupation, is not always properly related to the location of the original survey. The laying out of a series of tracts as original surveys by different individuals was not always made as a contiguous system, as generally accepted. The existence of hiatuses, gaps or vacancies and overlapping conflicts is common, and it is to determine such conditions that the surveys are made.

The aerial photos serve a purpose that could not be equaled in any other way and for modern methods are absolutely indispensable for performing the work with the greatest speed, economy and efficiency.

Record or Take-Off Work for Ownership Maps

Some areas, especially along the bayou settlements of South Louisiana, are considered impossible to map with any degree of satisfaction from the recorded descriptions of ownerships, as such descriptions are merely the names of the ownership "now or formerly" bounding the tract. These tracts always have a small frontage on the bayou and radiate back into the swamp or sea marsh to an estimated survey line usually designated as the 40 arpent line. A highway or road in most every case is found on each side of the bayou which makes this area accessible for rapid field identification of the control lines necessary to establish the arrangement of the ownerships on the 1,000 foot scale aerial photos.

Thus, the use of the photo grids in take-off work has established the difference between guesswork and facts. Two men can drive down the road adjacent to the bayou in one of these thickly inhabited areas, and with the tax rendition roll, township plat and photo grid, completely work out the ownership before a start could be made under the old guesswork system without the photos. The use of aerial photos in take-off work in any area simplifies the job and increases the speed, accuracy and economy.

Map Compilations

The general types of maps compiled by or for the petroleum industry by photogrammetric methods are roughly classified as follows:

1. *Ownership Maps*, by counties, parishes, township units, and producing oil fields or interesting areas.
2. *Base Maps*, for geophysical work—15 minute quadrangles—scale 1″ =2,000′.

3. *Regional Base Maps*, covering one degree longitude and several degrees of latitude, scale 1″=8,000′.

Ownership Maps

With the advent of aerial photogrammetry in the petroleum industry came the use of the higher standards of map compilation, such as regional enterprises where the refinements of geographic co-ordination could be effectively utilized, and at the same time incorporate all class "A" government map information into the system.

In Texas, the completed ownership maps are usually divided into counties by fractions, according to the economic ratio of a workable scale of 2,000′ or 3,000′ to the inch. The compilation is worked directly with and from the 1,000′ scale photos on which is identified all ownership and survey lines. The adjustment of the photos to geographic control is indeed a complex problem for most areas of Texas. The character of the land surveys in general imposes a responsibility on commercial photogrammetry that extends its general capacity. The irregular shapes and inaccurate field notes of these surveys leave the horizontal control feature entirely to the photo-continuity. In areas well supplied with geographic stations, the photographs can be kept very well adjusted, but where the stations are few and far between, it takes more of the refinements of this science to obtain satisfactory results. Railroad and highway traverses have been a vital asset in establishing or checking intermediate points and the general distribution between geographic control stations, but the most important factor in intermediate adjustment of horizontal control is the inherent characteristic of the photo-mosaic itself. Each mosaic assembly is a separate unit embodying its own discrepancies; therefore, with each unit adjusted in its relative placement and in co-ordination with geographic control, the errors of continuity are not accumulative but are localized and compensated within each unit. The foregoing discussion, I believe, illustrates the possibility of fairly satisfactory results even in areas where no ground control exists. The development of the supplemental controlled flights for stabilizing and controlling the horizontal correlation of large areas, without the extensive use of ground control, will, no doubt, be a key to help open up many of the inaccessible areas of foreign countries for oil exploration.

In Louisiana, a unitizing system was adopted for the State with a unit comprising two ranges of townships three tiers tall.

The units of the Gulf Coast area were compiled in about the same manner as was used in Texas. Much of the area consists of sea marsh and swamp land, but the network of winding bayous is very thickly populated and present many problems, as have been referred to under "take-off work". While this area was under the public domain of the U. S. Government, the rectangular co-ordinate system of surveying was done in such a "piece-meal", or fragmentary manner, that the surveyed dimensions furnish very little help in geographic correlation, but a sufficient number of geographic stations is scattered throughout the area to insure a well-balanced horizontal control.

The accuracy with which the actual reconstruction of the old original surveys can be made on the photographs, as related to the capacity to make such retracements on the ground, has been discussed under "cadastral surveys". The correlation that can be obtained by use of the aerial photos is so close to actual facts that they can be accepted for general mapping work without further question. Where irregularities are proved to exist, the discrepancies indicated on the maps give full warning that the title to the tracts must be cleared in the early stages of any proposed development.

In Northwest Louisiana and South Arkansas, Shell Oil Company's mapping project has been developed on a procedure different from those areas previously discussed. The completeness of the rectangular survey system and the symmetry of the ownerships of this area, in conjunction with the scarcity of geographic reference stations, presented an entirely different problem.

A series of basic strip maps, covering 2° longitude and 17½′ latitude were laid out to a modified conic projection on a scale of 2,000 feet to the inch. By the combined use of the photographs, railroad and highway traverses, township plats and geographic reference stations, the original township exteriors were correlated to this horizontal control system. Celluloid sheets were then superimposed on any particular unit and the data traced direct from the correlated base. The sections and ownership lines were then detailed on the tracing, subject to adjustment of conflicts with the photographs. After the lettering of ownerships, etc., was completed, the general culture was traced from the photographs in progressive stages, according to the necessary adjustments.

Many discrepancies were isolated by the use of the photos in conjunction with our other information. Without the photos, the basic system could never have been correlated to geographic control, and none of the culture or intermediate placement of ownerships could have been properly made.

The system we use in North Louisiana and South Arkansas is unquestionably the most accurate of the enterprises in which we have participated and can be recommended for use in any area where authentic survey information can be incorporated into the system to advantage.

Area or Field Maps

Area or field maps are usually a large scale map—500′ or 1,000′ to the inch, including only that part of a county or parish that is being developed. If the area has been surveyed by one of our field parties, the hard copy plat representing this work is reproduced as a base and extended to cover the entire area under consideration. Any conflicts between an area map and the regular ownership map are corrected on such ownership map, but as a general rule, the ownership maps compiled by photogrammetric principles reflect the detailed information commensurate with the scaled representation.

Other area or field maps are usually an enlargement of the county or area map, revamped for the various purposes for which it is to be used.

Base Maps

The base maps, compiled especially for use of geophysical work, are usually a direct delineation of the survey lines and fundamental culture, as they are reconciled or reflected on the 2,000′ photos. These maps cover four 7½′ photo grids adjusted to the exterior horizontal control co-ordinates, and are used in direct conjunction with the 2,000′ aerial photographs in the field work.

Regional Base Maps

Regional base maps, on a scale of 1″ = 8,000′, covering one degree of longitude and several degrees of latitude, are a composite of 15′ sheets worked direct from the 2,000′ photo grids.

The map is left skeletonized to permit the showing of geological information and only the outstanding cultural information and the larger surveys are designated by lettering. The other culture is indicated but is so light that it is very much in the background.

Pipe Lines

The use of aerial photos in pipe line work is the same as that for railroads or highways and can be used to great advantage in the location and contruction of new lines.

Photogeology

The uses of aerial photographs in photogeology are so extensive and cover such a large field that a book could be written on the developments and possibilities of this branch of the work.

The purpose of this work is to analyze the physiographical features on the surface of the earth, as such can be determined from the photographs, in order to locate or help locate prospective oil bearing structures.

In general, the drainage patterns, vegetation changes, color changes, soil anomalies and tracement of formational outcroppings are so interrelated in the geologic and metamorphic interpretations that a discussion of one would necessarily overlap the other. In justice to the subject, and to the profession using this branch of aerial photogrammetry, I will leave the discussion of this particular development to a better qualified technician.

Conclusion

In conclusion, I can say that I believe that of all the developments and refinements added to the surveying and mapping science during the past century, "Aerial Photogrammetry" surpasses them all. As a matter of fact, it is an acceptable and indispensable phase of all branches of the petroleum industry.