Arizona Materials Inventory Reports

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This paper presents a description of the form and content of the Arizona Materials Inventory reports. Each report covers one of 14 Arizona counties that range in size from approximately 1,400 to nearly 10,000 sq mi. These are subdivided into map sheet areas averaging 30 by 36 mi. A pit and quarry map locates all known sources by serial number and appropriate symbol. A photogeologic map shows the relationship of the sources to the surface geology. A data sheet lists all sources in the area by serial number and describes location, type of material, mechanical analysis, and evaluation of each.

The reports are technical, but are written so that they may be used by the non-engineer or geologist materials prospector.

•TEN to fifteen years ago a few States had found that a highway materials inventory was a useful tool in the systematic location of materials sources. Use of this tool developed slowly until the mid-1950's when the demands of the Interstate Highway program made an inventory a virtual necessity. The huge increase in mileage due to the new program in addition to the accelerating normal program made the location of adequate materials sources a real problem. To develop these new sources rapidly required that all existing pits and quarries be reviewed to determine how many had been exhausted or lost and what quantities and types of materials remained. Once plotted, this information is important to nearly all phases of highway planning, design, construction and maintenance.

The value of the inventory is twofold. The initial result is that any lack of either quantity or type of construction materials in a given area is readily apparent. An accurate knowledge of the quantity, type and location of available materials is essential to planning and design. Without it a proposed route may have to be delayed until the design can be adjusted to fit the existing supply. If these factors are ignored, the added costs of excessive haul distances are a certainty. By contrast, a review of all known sources often reveals the presence of a large, low grade source that can be judiciously used or upgraded at considerable savings. This not only affects economy but also conservation of high grade materials which even now is becoming an important factor in many places.

Once the areas deficient in either type or quantity of materials are indicated, the inventory can also act as a guide for prospecting for the required sources. This is particularly true if the inventory mapping includes surface geology. Barren or unlikely areas can be quickly eliminated and the prospecting concentrated in more promising areas. The recording of all test data also eliminates duplication of work, either at the same site or over the same area looking for a different type of material.

INVENTORY METHOD

Basically, a highway materials inventory consists of assembling all available information on all known materials sources and recording these data in a useful form. Usually this is done by plotting the numbered sources on a map and summarizing the laboratory and field testing results on a data sheet. These are customarily combined to form a folio or report.

Paper sponsored by Committee on Surveying, Mapping and Classification of Soils.

From this framework is developed the form of the inventory best suited to local needs. Certain types of information are stressed. The breadth of coverage is designed to shape the report to the purpose intended, which in Arizona is to provide detailed information on the location and test results of all sources by county as well as by their relationship to surface geology.

This broad coverage, rather than strip maps, is used because of the availability of base maps on county units and the desire to show the relationship between the materials sources and the surface geology. Sand and gravel are used primarily as construction materials in Arizona, so that base maps covering a large area are desirable to show the stream pattern to indicate the origin and therefore the general composition of the alluvial deposits.

Materials sources in Arizona are developed from the central Materials Division office by seven field crews working under the supervision of two materials field engineers. The list of future projects scheduled by the Plans Division is used to program the work, each foreman being assigned several projects suitable to his type of equipment in a general area. The plan and profile of a given project are studied in the office by a field engineer to determine the materials and design requirements. If the materials file shows nearby existing sources, they will be retested and enlarged if necessary. If no suitable sources exist, the quantity and desired location of materials needed are given to the exploration foreman to investigate along with the required centerline testing. When the drilling, test pitting and sampling on the pit areas and centerline are complete, the field engineer inspects the work noting soils, rock, and terrain features to classify excavation for design purposes. When the laboratory tests on the proposed materials sources are completed the boundaries of ample suitable material are established, the sources are assigned pit serial numbers and are then, hopefully, sent on for acquisition. Often geological and aerial photo studies are made to locate sources, and the testing augmented or directed by geophysical studies.

Data on all known materials sources are filed in the central Materials Divisision office. Each source is identified by a serial number assigned chronologically after testing and approval. The folder on each source contains a pit sketch map showing the pit boundaries, any test holes, the haul road, and the surveyed tie to highway stationing. The legal description and plat and all laboratory test results are included. This information is cross-filed by serial number and by project. The location is also plotted on a highway index map for rapid location.

This reservoir of data supplies nearly all the materials information needed to make a materials inventory. Of only slightly less importance is the availability of a suitable base map on which these data can be plotted. By good fortune, the Photogrammetry and Mapping Division of the Arizona Highway Department is currently revising the statewide General Highway Map series on a county basis. These extremely accurate maps are made photogrammetrically from 1953 Army Map Service aerial photography and U.S. Geological Survey and U.S. Coast and Geodetic Survey control. The basic unit is a lithographed map sheet covering an area of approximately 30 by 36 mi at a scale of $\frac{1}{2}$ in. = 1 mi. Each county series or folio contains from 2 to 22 map sheets, depending on area. To date, maps for Maricopa, Santa Cruz, Gila, and Pima Counties have been completed in that order, covering the south-central portion of the State.

These maps can be produced at the rate of only one to two counties per year. Maps of the first three counties had been or were being published when the materials inventory began so that no delay was experienced until recently. Publication of the Pima County materials inventory report was delayed several months waiting for maps, and it is now evident that future inventory work can proceed only at the pace set by the Photogrammetry and Mapping Division.

The materials inventory and the published reports are made by the Engineering Geologist of the Materials Division who is assigned to the project permanently. This work is under the general supervision of the Engineer of Materials. Until recently a geological assistant was also assigned to the project but was reassigned when it became evident that the program would have to adopt a much slower pace. As is the case with most other States making an inventory, this work is being done in Arizona

in cooperation with the U.S. Bureau of Public Roads and is supported, in part, by the 1½ percent (HPS) funds. These funds have purchased a complete set of aerial photographs giving statewide coverage and are also used for salaries, travel expenses and publication costs.

DESCRIPTION OF REPORT

The materials inventory reports are published as a folio 14 by 17 in. in size bound along the left edge with a plastic multi-ring binder. All printing is done by Highway Department facilities using the offset method. The large size was chosen for two reasons: large maps give a continuity for study of the relationships between the surface geology and the materials sources; and the annoying folding and unfolding of maps is eliminated.

The reports contain the following sections, given in order: Introduction, Geologic History, Map Sheet Groups, and Appendix. Of these, the map sheet groups are the most important as they contain the locations, descriptions, and test data. The other sections are essentially explanatory to aid in the use or explanation of the technical data.

Introduction

This section describes the contents of the report and their purpose. Brief descriptions of the geography of the county and the general type of materials used are included. The explanation of the method of preparation of the report goes into some detail so that the reader may judge the accuracy and validity of the data included.

Geologic History

This section is important and probably the most difficult to prepare. Its purpose is to give the reader a concise background of the geologic processes forming the topography of the county and the sequence of the rock strata. This background information is intended to explain the origin of the materials in known sources as well as to provide a basis on which new sources can be located by deduction. Care is taken to make this information technically accurate, but in non-technical terms where possible. It has been found that most engineers and materials prospectors are interested in this information and are by nature observant. A surprising number have formed their own theories to guide them in field exploration.

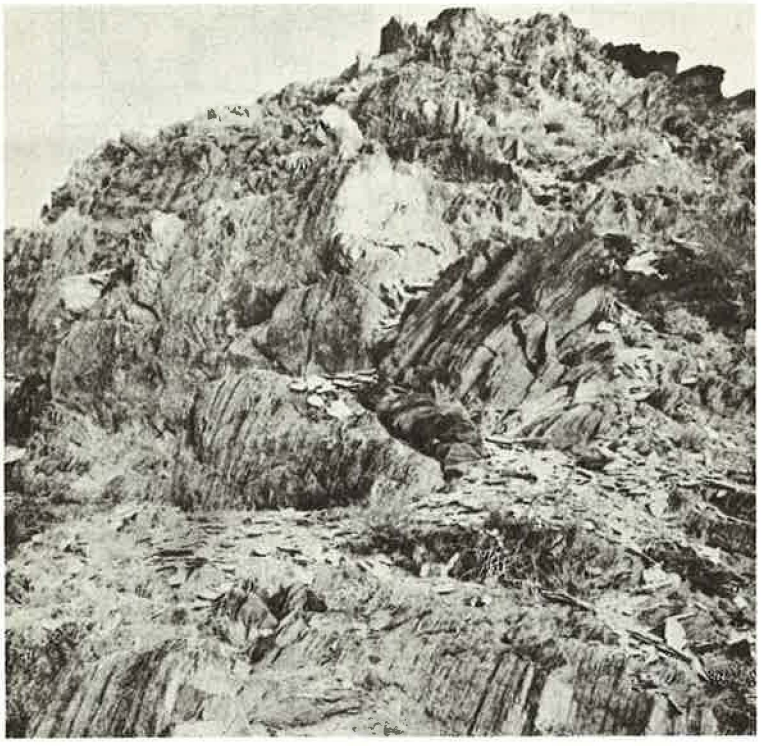
To supplement the written history, one or more geological cross-sections are given on the facing page to clarify the relationship and location of the formations described.

A subsection gives brief descriptions of the geologic formations mapped on the following geological maps. These descriptions are given under the identifing map symbol and describe the type of formation, the color, size, or appearance characteristics, and contain a special note as to what kind of mineral aggregate will be derived from it. An opinion is included as to probable plasticity and quality of the fines. These descriptions provide enough information so that the major units can be recognized in the field. To aid in recognition, a series of large photographic illustrations of the more important formations are included in the map sheet groups. The captions point out the recognition features noted in the formation descriptions (Fig. 1).

Map Sheet Groups

As previously noted, this section contains all the data on the location, and tests of the materials sources in the county covered by the report. This information is given on a pit and quarry map, geological map and test data sheets. Included are the photographic illustrations described in the previous section. Each group consists of one map sheet area so that a report will contain two or more groups to cover the entire county that is the subject of the report.

The base maps used for both pit and quarry and geological maps are 18- by 24-in., map sheets published by the Photogrammetry Division to the scale of ½ in. = 1 mi.



Schist — mapped as Sch, one of three oldest rocks in the State (Pre-Cambrian). Thin, even layers or lamina are characteristic. Lamina are usually flat, but are here faulted into a vertical position. Formed by heat and pressure from shales or volcanic rocks. Forms light-colored hills.

Figure 1.

These contain the stream and drainage pattern, transportation routes, and hatched locations of the higher mountain areas.

All known materials sources in a given map sheet area are plotted on the pit and quarry map (Fig. 2) using appropriate symbols to designate the type of material and ownership. A black round dot indicates mineral aggregate (MA) or aggregate base (AB). A vertically divided, half black, half white round dot represents a source of select material. The round dots indicate only sources owned or controlled by the Arizona Highway Department. Solid and divided square dots for the same materials indicate Federal or county ownership. Commercial sources are marked by a round dot divided into quarters. Because borrow material is usually available on each project as needed, all symbols designating it are circular. These contain a number from one to seven denoting quality of the material based on the Arizona Highway Department base thickness chart of 1959. These ratings are: 1-2-3, good; 4-5, fair; 6-7, poor. Any exhausted or depleted pit or quarry is marked by a circled M indicating "mined out." All sources are identified by serial numbers placed beside or below the source symbol on the map.

The geology map (Fig. 3) for the same area is made on an identical base map. The larger rock exposures and outcrops are identified by the standard formation name abbreviation and a geometric pattern which is printed in color for clarity and emphasis. The younger alluvial deposits are identified by name abbreviation only for the sake of simplicity. The major faults in the area are shown, but otherwise no structural features are included. The larger rivers, washes and intermittent streams are marked by a gravel or dotted pattern denoting a usable quantity of granular material. Symbols

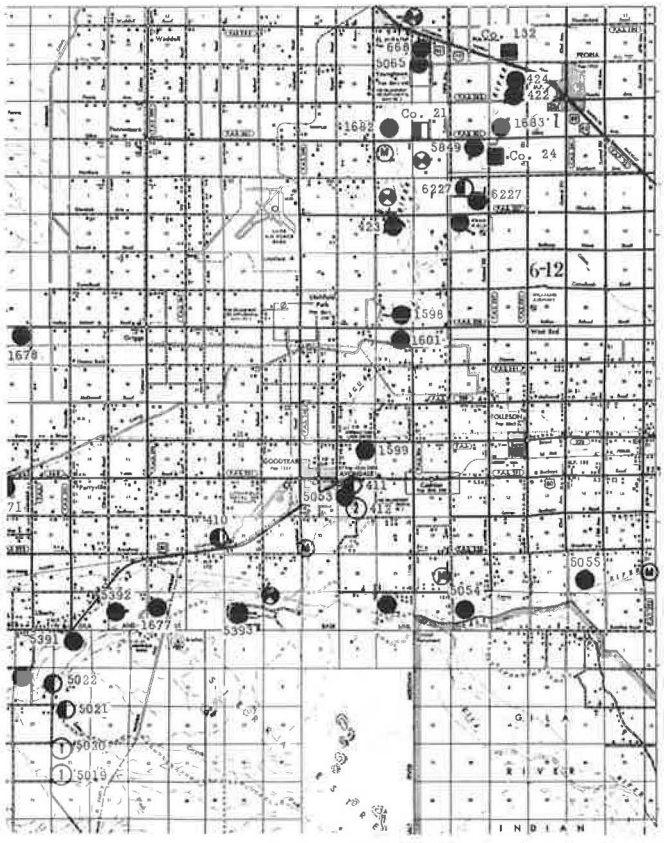


Figure 2. A portion of the pit and quarry map.

on this pattern identify various types of material which are explained in the legend. The mapping of the geological formations and the stream pattern to this point is done from interpretation of aerial photographs and use of existing geological and soil survey maps. This information is then checked in the field with particular attention to the type and origin of gravels in the stream channels and the formational limits. This checking is detailed along highways in the area, but is less thorough in mountainous or inaccessible areas where terrain and distance make location of new materials sources unlikely.

At this stage the materials source locations from the pit and quarry map are marked on the geologic map by a donut-shaped universal symbol. The sources are field checked to see if they still exist, to estimate the amount of material still available, and to check the accuracy of the location marked on both maps. In the report, the pit and quarry and the geological maps are on facing pages for easy reference and comparison. In later reports a 6-in.-wide stub page is bound between them giving the legend for the geologic map on one side and the explanation of the materials source symbols on the other. The proper side is face up as it is turned to clear one map or the other.

The data sheet (Fig. 4) contains the location and test information of the sources shown on the pit and quarry maps. Each pit and quarry map in each map sheet group is accompanied by at least one data sheet. As a rule all the sources shown on a pit and quarry map can be listed on a single 26-line data sheet. Exceptions are map sheet areas containing several major highways or urban areas, which may require up to six data sheets to describe the large numbers of sources customary in these areas.

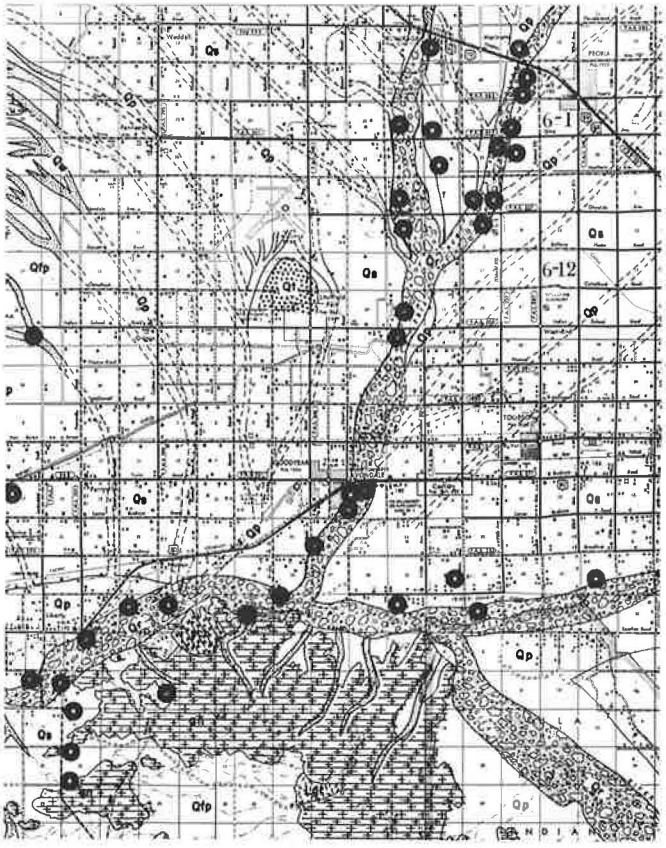


Figure 3. A portion of the geology map.

The data sheet is the heart of the inventory report. It presents a summary of the laboratory and field information on file in the central office on each source shown on the pit and quarry map. This information is shown in the form of a table in vertical columns grouped into three sections. All information on each source, identified by the pit serial number, is shown on one horizontal line. The location section gives the legal description, highway number, project number, and stationing on the project. The type of material section notes whether it is sand, gravel, rock or clay; the use for which it is intended and was tested, as well as an estimate of the yardage available. The Atterberg limits, sieve analysis and AASHO soil group are given for a representative sample from each source. Succeeding columns give the averages of the plasticity index and percent passing the number 200 sieve for all samples tested from the source. Also, the quality of the source from poor to excellent, is judged from the information on file or field inspections and given in the last column. Where no laboratory test data are available in the materials or project files the locations and type of material information is given and the words "No Data Available" are written across the test data columns. This allows the source to be located in the field where some estimate of quality can be made by eye.

Appendix

This final section contains explanatory charts and maps for reference. The pages of the appendix are not shown in this paper, but some features warrant discussion. The page on Standard Specifications of the Arizona Highway Department is intended for reference by municipal, county or Federal personnel using the report. Current

TEST DATA SHEET
MAP SHEET NO. 8

NOTE: A.B. – AGGREGATE BASE. M.A. – MINERAL AGGREGATE. S.M. – SELECT MATERIAL.

LOCATION							TYPE OF MATERIAL			TEST DATA														QUALITY
LEGAL DESCRIPTION			PIT NUMBER	PROJECT NUMBER	ROUTE NUMBER	PIT LOCATION BY STATION	PROPOSED USE OF MATERIAL	EST. QUANTITY CU/YD	KIND OF MATERIAL	REPRESENTATIVE SAMPLE										AVERAGE OF TESTED SOURCE				QUALITY OF MATERIAL (FOR USE LISTED.)
												ATTR'BG LIMITS		SIEVE ANALYSIS % PASSING										
TOWNSHIP	RANGE	SECTION								HOLE NUMBER	DEPTH OF SAMPLE	L.L.	P.I.	#200	#40	#10	1/4"	1"	A.A.S.H.O. SOIL CLASSIF.	DEPTH OF SOURCE	AVERAGE OF VALUES P.I.	AVERAGE OF VALUES % PASS #200	ABRASION 500 REV	
2S	4W	23	1527	FI-159(1)	U.S.80	2200'Lt.Sta.6230	Select	35,000	Sand, Gravel	4			NP	2	10	47		95	A-1-a	0	0-2	0-4	32	Good
3S	4W	11	1526	FI-159(1)	U.S.80	600'Rt.Sta.6057	Select	11,000	Sand, Gravel	3			NP	6	20	50		99	A-1-a	0	0-4	2-37		Good
3S	4W	14	1525	FI-159(1)	U.S.80	4700'Rt.Sta.5979	AB/MA	20,000	Sand, Gravel	1			NP	6	17	43		96	A-1-a	2	0-1	2-16		Good
5S	4W	33	1503	FI-159(1)	U.S.80	1400'Rt.Sta.5210	AB/MA	60,000	Sand, Gravel	6			NP	6	24	50		85	A-1-a	0	NP	2-9	29	Good
5S	5W	35	510	FI-156	U.S.80	700'Lt.Sta.5026	Select	7,000	Sand,Gravel	4			NP	12	32	56		88	A-1-a	2	NP	2-31		Good
6S	2W	19	5610	I-0022(7)	St.84	1000'Rt.Sta.654	AB/MA	50,000	Sand, Gravel	5			NP	5	20	48		91	A-1-a	0	NP	1-17	31	Good
6S	2W	20	5612	I-0022(7)	St.84	1700'Rt.Sta.743	Select	27,000	Sand, Gravel	2			NP	4	16	48		91	A-1-a	0	NP	1-10	34	Good
6S	2W	35	5617	I-0022(7)	St.84	2300'Rt.Sta.900	AB/MA	80,000	Sand, Gravel	3			NP	3	15	48		96	A-1-a	0	NP	1-8	35	Good
6S	3W	7	5642	I-0022(8)	St.84	2640'Rt.Sta.360	Select	38,000	Gravelly sand	5			NP	6	23	54		94	A-1-a	0	NP	4-14		Good
6S	3W	14	5648	I-0022(13)	St.84	800'Rt.Sta.563	Select	48,000	Gravelly sand	9			NP	6	22	59		92	A-1-a	0	NP	2-15		Good
6S	3W	15	5646	I-0022(13)	St.84	300'Lt.Sta.514	Select	53,000	Gravelly sand	6			NP	4	19	52		89	A-1-a	0	NP	2-33		Good
6S	4W	34	5637	I-0022(8)	St.84	4 Mi.S.Sta.202	AB/MA	73,000	Sand, Gravel	13			NP	12	25	46		82	A-1-a	0	NP	3-24	28	Good
7S	1W	5	5625	I-0022(7)	St.84	2000'Rt.Sta.1070	Select	50,000	Sand, Gravel	6			NP	4	18	49		92	A-1-a	0	0-2	1-17	32	Good
2S	4W	35	1532	FI-159(1)	U.S.80	600'Rt.Sta.6174	Borrow	20,000	Clayey sand	5		7	11	29	43	68		99	A-2	0	6-13	10-44		Fair
3S	4W	3	1527	FI-159(1)	U.S.80	700'Lt.Sta.6091	Borrow	20,000	Silty sand	2			6	23	38	66		100	A-1-a	0	2-7	0-40		Good
3S	4W	10	1528	FI-159(1)	U.S.80	500'Lt.Sta.6019	Borrow	18,000	Gravelly sand	4			2	15	30	54		100	A-1-a	0	0-3	8-17		Good
3S	4W	26	1522	FI-159(2)	U.S.80	700'Rt.Sta.5899	Borrow	15,000	Gravelly sand	2			4	19	34	55		100	A-1-a	0	0-4	12-30		Good
3S	4W	34	1520	FI-159(2)	U.S.80	800'Lt.Sta.5840	Borrow	15,000	Gravelly sand	2			6	19	31	55		98	A-1-a	0	3-9	17-23		Good
4S	4W	11	1515	FI-159(2)	U.S.80	1000'Rt.Sta.5735	Borrow	15,000	Sand, Gravel	3			NP	8	22	48		90	A-1-a	0	0-2	2-12		Excellant
4S	4W	26	1514	FI-159(2)	U.S.80	600'Rt.Sta.5568	Borrow	20,000	Gravelly sand	No data available														
5S	4W	2	1509	FI-159(3)	U.S.80	600'Rt.Sta.5482	Borrow	18,000	Gravelly sand	2			NP	22	43	66		99	A-1-a	0	NP	16-28		Excellant
5S	4W	10	1510	FI-159(3)	U.S.80	600'Rt.Sta.5429	Borrow	20,000	Gravelly sand	4			NP	17	32	70		100	A-1-a	0	NP	15-24		Excellant
5S	4W	28	1504	FI-159(3)	U.S.80	600'Rt.Sta.5251	Borrow	20,000	Gravelly sand	3			NP	17	36	59		94	A-1-a	0	NP	8-17		Excellant
6S	2W	20	5611	I-0022(7)	St.84	400'Lt.Sta.6901	Borrow	80,000	Sand, Gravel	4			4	10	18	47		99	A-1-a	0	2-4	6-28		Good
6S	2W	36	5620	I-0022(7)	St.84	900'Rt.Sta.9631	Borrow	85,000	Sand, Gravel	4			6	9	21	47		90	A-1-a	0	0-15	9-53		Good
6S	3W	16	5645	I-0022(13)	St.84	600'Rt.Sta.4581	Borrow	90,000	Gravelly sand	5			NP	9	33	62		90	A-1-a	0	NP	4-11		Excellant

Figure 4.

specifications for mineral aggregate, aggregate base, and select material are listed. The quality of a source noted in the report is based on these specifications and therefore it may be entirely suitable under looser specifications or for another purpose.

An explanation of the serial or pit number system is also included for the information of the non-highway department user. A table showing the date each hundredth serial number was assigned is given so that rough dating of the prospecting and testing is possible without access to the central file records.

An AASHO subgrade classification chart is printed on the facing page to show the origin of the group index figures given on the data sheets. By checking the soil group against the chart further information on the type or character of the material may be obtained.

The aerial photo index is intended to provide a quick method to locate the aerial photos needed for more detailed study of any part of the pit and quarry or geological map areas. Flight lines are plotted across an outline of the county with the flight and photo numbers noted at each end of the line at the county boundary.

Topographic map coverage of the same county is plotted on an identical outline. The outline of U. S. Geological Survey quadrangle sheets are dashed in to scale on the outline and identified by name and date. This index is also intended as a quick source of further information for detailed or additional study in the area.

COVER

With the exception of the first report, the cover has consisted of a margin-to-margin photograph on which the black title is overprinted. The photograph used is an aerial or distance view of some prominent geological feature of the county covered by the report. It is printed in one color on white cover stock to make the report more attractive and to aid in identification.

The title format overprint is standard to all reports to indicate each is only one segment of the statewide inventory. The county name varies but its size and position penetrating the State outline is constant. This overprint and the plastic binder are black to set off the colored photograph.

USE OF REPORT

Distribution of the materials inventory reports is restricted to engineering personnel of the Arizona Highway Department. They can be issued to engineering personnel of Federal or municipal agencies and have been sent to out-of-state highway departments or universities when requested. This restriction is necessary to protect many of the sources listed that are not owned and controlled outright by the highway department. Because 86 percent of Arizona land is owned by Federal, State, or local government units, most of the sources are used on a permit granted for a definite period of time of either months or years. Those sources on private land are used on a royalty basis. Because permits expire or can be assigned to others, the restriction of the reports containing locations and test results is necessary to protect the investment of time and money used to develop them. In or near population centers this problem is acute because of competition for sand and gravel and is only slightly less in areas of scarcity. It is unfortunate that information gathered by a public agency must be withheld from the public but in this case the saving of tax dollars seems to justify.