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The information contained in this circular was gathered by a unit of the WPA Geological Investigation Project, sponsored by The University of Texas, Bureau of Economic Geology. The purpose of this survey is to assemble information concerning the mineral resources of Texas and make it available to the public. It is hoped that this information will be a contribution to the industrialization of the State. The following report is based on information obtained in Llano County by Work Project No. 18509.

A NEW FELDSPAR DEPOSIT IN LLANO COUNTY, TEXAS*

by Carl Chelf, Supervisor

Introduction. — Feldspars represent one of the most abundant groups of minerals and account for approximately 60 percent of the igneous rocks of the earth, according to Clark.[1] All are grouped in a series of related aluminum silicates that contain varying amounts or proportions of potash, soda, and lime. The three principal types are: potash feldspars (microcline and orthoclase); soda feldspar or albite; and soda-lime feldspars (plagioclase). Feldspars as a group are easy to recognize, but individual species such as albite, orthoclase, or microcline are difficult to separate by ordinary field identification. However, when well-developed crystals are found, or crystals have definite twinning, determination is simplified. Some varieties have unusual features that aid in identifying them; a variety of orthoclase called adularia, for example, possesses opalescence and is generally known as moonstone. A variety of microcline known as amazon stone or amazonite is usually some shade of green. The feldspars crystallize in the monoclinic and triclinic systems. Their physical properties are strikingly similar. Specific gravity is from 2.55 to 2.75, and hardness is from 6 to 6.5 in Mch's scale. The most obvious property of feldspar is its good cleavage with glistening faces. Another common spar type, an intergrowth of feldspar and quartz, is graphic granite or corduroy spar, the latter name being derived from the appearance of cleavages when viewed in a certain manner. A specimen from Badu Hill is shown in this report (fig. 3). Although the feldspars are very abundant, the only deposits that are worked to any extent anywhere at the present are the pegmatites or coarsely crystalline dikes where natural segregation of the constituents makes it relatively east to obtain the feldspar with a minimum of free quartz, mica, tourmaline, garnet, or other iron-bearing substances that act as impurities. Black mica (biotite), garnet, and tourmaline are very undesirable and should be removed.

Commercial grades. — Commercial grades of feldspar are intergrowths of two or more types of spar. A common spar of this type is perthite, an intimate intergrowth of orthoclase or microcline with albite. Marketable grades depend largely upon the specifications set up by buyers of crude or unground spar and ground spar. In a rough classification of commercial grades, feldspars are divided into three or four principal types: glass spar, pottery spar, and glaze spar. The following information, condensed from Metcalf,[2] gives some of the usual standards for these grades: In glassmaking, spar is used primarily as a source of alumina, and either soda or potash spar is acceptable; some glassmakers prefer soda to potash. No. 2 glass spar must contain at least 17 percent Al_2O_3 and not more than 0.1 percent Fe_2O_3. The minimum for total alkalies, Na_2O plus K_2O, is 11.5 percent. For No. 1 glass spar the free-quartz content is limited to a maximum of 6 percent. Calcium is usually quite low, 2 percent or less CaO. Analyses of pottery spars range from 73 to 65 percent SiO_2; 12.5 to 3.5 percent K_2O; 1.5 to 6.5 percent Na_2O; and 0.10 to 0.05 percent Fe_2O_3. Spars high in potash are usually preferred. Glaze spar, on the other hand, is typically high-soda and contains 4 percent or more Na_2O.

Uses[3]. — "Nearly seven-eighths of the feldspar produced in the United States is used as a flux in the production of glass, pottery, enamel and sanitary ware, brick, and tile. It melts without becoming entirely fluid and upon recooling becomes a strong, colorless or only slightly colored glass. In most pottery it is a part of both body and glaze, and its cheapness of late has enabled it to a considerable extent to supplant clays and other crude materials. Feldspar is one of the essential ingredients in opalescent glass. It is used in dentistry for artificial teeth and porcelain inlays. Enamel for bath tubs, wash bowls, and other purposes contains considerable feldspar. It is one of the principal ingredients in electrical insulators. Other uses are for scouring soaps and window cleaning compounds, as binder for abrasive wheels, as a surfacing for prepared roofing, as a coating for stucco and concrete, as sand-blast, for poultry grit, foundry facings, floor covering, sandpaper, paint and wood filler, in terra cotta, and as a flue-dust arroster."

Occurrence in Llano County. — The Llano region[4] in central Texas includes all of Llano County and parts of eight other counties. Exposures of pre-Cambrian formations of the region are part of a structural dome made up largely of sediments including sandstones, shales, and limestones, now altered to quartzite, gneiss, schist, dolomite, and limited quantities of magnesite. This highly altered series has been extensively intruded by granites, aplite, pegmatite dikes, dioite, and gabbro. Llano County, as well as other counties in the area, contains an abundance of pegmatite dikes, but feldspar production from them is hampered by size, poor segregation of feldspar, too high quartz to feldspar ration, or high iron content.

*Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project Nos. 165-1-66-695 and 265-1-66-214.

[1]Feldspar paper: Reference to Clarke — "Analyses of Rocks," U.S.G.S. Bull. 168: 308 pp., 1900.

[2]Metcalf, R. W., Marketing feldspar: U.S. Bur. Mines, Inf. Circ. 7184, p. 3, 1941.

[3]Sellards, E. H., and Baker, C. L., The Geology of Texas, Vol. II: Univ. Texas Bull. 3401, p. 414, 1934 (1935).

[4]For a complete account of the geology of the Central Mineral region, see The University of Texas Bulletins 3232 and 3401; Paige, Sidney, Description of the Llano and Burnet quadrangles: U.S. Geol. Surv. Geol. Atlas, Llano-Burnet folio (No. 183), 1912; Stenzel, H. B., Structural study of a phacolith: Report of XVI International Geological Congress, Washington, 1933.

Mining. — Feldspar has been mined and shipped from Llano County for the past ten years by Mrs. Tillie Badu Moss. Other individuals and companies, notably the Llano Feldspar Corporation, have made attempts to mine and market crude or ground spar, but the ventures failed either because of the lack of a good quality pegmatite feldspar or sufficient quantity for steady production. Before the discovery of the Badu Hill pegmatite in 1936, the production to that date had been derived from two localities, namely, the Bill Williams dike, 2 miles west of Kindsland, and Baringer Hill, the famous rare-earth mineral dike located near Bluffton. Many carloads of good quality feldspar mentioned by Hess[5] had been piled to one side at Baringer Hill incident to mining operations in the recovery of rare-earth minerals, and this was largely shipped before the locality was covered with water impounded by Buchanan Dam. Landes[6] described the "normal pegmatite" of Baringer Hill as consisting of milky quartz and perthitic microcline. According to Landes, feldspar masses occurred that were as great as 30 feet across. The Bill Williams dike, like Baringer Hill, intrudes granite. The quartz-feldspar ratio of the Williams locality is approximately 2 to 1. The entire production of feldspar in Llano County is derived at present from Badu Hill, a description of which occurrence follows:

Badu Hill pegmatite. — This pegmatite dike was discovered by Mrs. Tillie Badu Moss in 1936 and is named for her father, the late N. J. Badu, pioneer in mineral development in Llano County. It is located approximately 4.5 miles S. 35° W. from Baringer Hill and about 1 mile due north of Beverley. The loading point is Hobart junction, 1 mile from the mine. (fig. 1). The dike intrudes a long narrow belt of Packsaddle shists and marbles which is hardly more than 0.5 mile wide, bounded on either side by coarse-grained granite. The granite is part of the Lone Grove mass as mapped by Paige.[7] The dike is a slightly elongated mound rising approximately 50 feet above the surrounding area and is essentially concordant, largely cutting steep-dipping siliceous dolomite beds. The dike stands above the less resistant schists, granite, and carbonates. Although the intrusion contacts with country rock are vague due to accumulated overburden and undergrowth, the dimensions of the dike are essentially as follows: length, 700 feet; greatest width, 305 feet, the longer axis being oriented east-west. A minor intrusion of good feldspar and quartz intrudes dolomite about 200 feet east of the limits shown on the detailed map of the dike. Other minor dikes of light-colored feldspar and quartz have intruded the extensive dolomite beds west of the main dike.

Two main rock types are readily distinguished as shown on the detailed map of the hill (fig. 2). An area designated as coarse pegmatite consisting largely of light pink to very light brown microcline and banded milky quartz lies near the center of the intrusion with a peripheral zone of graphic granite completely surrounding it. Mining is in the coarse microcline-quartz zone. Quartz occurs mainly as isolated or segregated islands with the long axes usually parallel with the schists and marbles of the country rock. A few large feldspar crystals have been found in mining operations that had normally developed microcline faces over a foot in length, but the bulk of the material consists of smaller crystals distorted by close intergrowth. The feldspar has been taken from the open pit mine in an almost continuous body for 130 by 70 feet to an average depth of 8 feet with but few masses of quartz interfering with regular mining. The quartz of the large masses had distinct white bands which are rather uniformly one-fourth to one-eighth inch in width. The quartz of Baringer Hill as described by Hess[8] is strikingly similar to the Badu occurrence. Hess concluded that "the milky white bands (as contrasted with the clear areas) are due to small liquid inclusions, many of them containing bubbles which either do not move from change of inclination of the fragment containing them or do so but slowly."

Feldspar. — The feldspar is rather uniformly light pink to very light chocolate in color and is visibly perthitic in certain areas. Crystal development and twinning show that the bulk of material is microcline. No orthoclase crystal development was found, and it is believed to be entirely absent. Free quartz as visible crystals or inclusions is rarely found within single or twinned crystals. For this reason, little hand sorting to lower free quartz content is necessary. The dike is notable in the almost total absence of such substances as biotite, garnet, beryl, and tourmaline. Black mica or biotite was found only in tests examined in the graphic granite area, and this was largely decomposed to a depth of 6 feet in a test examined on the southeast side of the dike. The quality of this spar is shown by the following chemical analyses from representative samples taken from the mine.

Analyses of sample by the Bureau of Industrial Chemistry, The University of Texas

	Percent
SiO_2	69.09
Al_2O_3	20.16
Fe_2O_3	trace
MgO	0.02
CaO	0.64
Na_2O	3.50
K_2O	7.72
H_2O at 110° C.	0.28

[5]Hess, F. L., Minerals of the rare-earth metals at Paringer Hill, Llano County, Texas: U.S. Geol. Surv. Bull. 340, p. 289, 1907.
[6]Landes, K. K., The Baringer Hill, Texas, pegmatite: Amer. Min., vol. 17, pp. 381-390, 1932.
[7]Paige, Sidney, Description of the Llano and Burnet quadrangles: U.S. Geol. Surv. Geol. Atlas, Llano-Burnet folio (No. 183), 16 pp., maps, 1912.
[8]Hess, F. L., *op. cit.*, p. 288.

Analyses of samples by Libby-Owens-Ford, Charleston, West Virginia.

Sample No.	1	2	3
	Percent	*Percent*	*Percent*
SiO_2	65.08	—	—
Al_2O_3	19.19	19.56	19.22
Fe_2O_3	0.088	0.139	0.084
MgO	0.05	—	—
CaO	0.06	—	—
Na_2O	2.67	—	—
K_2O	12.54	—	—
P_2O_5	0.13	—	—
Ign. loss	0.3	—	—

Analysis of sample by Evans W. Buskett, Metallurgist, Webb City, Missouri.

	Percent
SiO_2	63.4
Al_2O_3	19.31
Fe_2O_3	.084

In a communication by a chemist of the Libby-Owens-Ford Company to the operator of the Badu Hill mine, the similarity of the feldspar to that of Keystone, South Dakota, was mentioned. The Badu feldspar is suitable for glass as well as pottery spar.

Other minor features. — Occasional vugs, usually less than a foot in size in any direction, are lined with well developed clear or delicate pink microcline crystals, smoky to clear ghost and scepter quartz crystals, and small hexagonally developed books of muscovite or a similar mica. Such cavities usually carry small quantities of very plastic yellow clay. White kaolin is also present in small areas of the mine, particularly on the east wall of the present pit. Two small pieces of rare-earth minerals have been found in the mine.

(Supply of maps mentioned now completely exhausted.)