META-ARKOSE BOULDER FROM BLAKELY SANDSTONE (ORDOVICIAN), BENTON QUADRANGLE, ARKANSAS

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Reprinted for private circulation from

ARKANSAS GEOLOGICAL COMMISSION

SYMPOSIUM ON THE GEOLOGY OF THE OUACHITA MOUNTAINS

VOLUME I

Stratigraphy, Sedimentology, Petrography,
Tectonics, and Paleontology

1977

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INTRODUCTION

During the Ouachita Symposium Sessions at the 7th Annual Meeting of the South-Central Section of GSA held at Little Rock, Arkansas, April 5-7, 1973, the subject of certain "granite" or "meta-arkose" boulders from the eastern Ouachita region came up repeatedly. Inasmuch as the "meta-arkose" interpretation was based on a petrographic description by me, the chairman of the symposium asked me to submit a description of that material for this publication. The petrographic study was based on a single thin section and two hand specimens collected by the Arkansas Geological Commission from boulders at the Uebergang uranium prospect in the Benton Quadrangle, northern Saline County, Arkansas. The following location and field description of the occurrence is by C. G. Stone.

LOCATION AND FIELD DESCRIPTION

The Uebergang uranium prospect consists of very small trenches and pits made in 1955 on a radioactive anomaly primarily along the south flank of a small hill in the SE¼, sec. 3, T. 1 N., R. 15 W., about 1000 feet north of the dirt road (old Gray Hill School area) in northern Saline County, Arkansas.

Numerous vuggy quartz-feldspar and some feldspathic quartzite boulders, up to 5 feet in diameter were exhumed at the site from a decalcified (?), red clay residuum in a sequence of black, glossy chert, siltstone, and gray "talcose" shale apparently at the top of the Blakely Sandstone of probable Lower Ordovician age. A thorium mineral in the boulders and clay was indicated by the U. S. Geological Survey as the primary cause of radioactivity (maximum of 1.5 percent Th^{232} and 0.019 percent U_3O_8).

MEGASCOPIC DESCRIPTION

The rock is moderately weathered, friable, very pale orange but locally iron stained, coarse grained granitic textured material. Quartz and a non-striated feldspar are the only recognizable minerals. The quartz occurs as colorless, apparently anhedral, single grains or clusters of grains up to 1 cm in maximum dimensions. Feldspar appears as subhedral blocky crystals 2x5 to 5x10 mm. It is turbid and shows some alteration but some cleavages are still lustrous. Many cleavages, however, are partially covered with a film of alteration products. No ferromagnesian minerals are identifiable megascopically but there are some small dark grains. The limited amount of iron staining would indicate either a very low initial ferromagnesian content or thorough removal. About five percent of the rock consists of partially filled interstitial voids ranging from 1 to 4 mm. Most of these voids are straight sided with shapes controlled by adjacent feldspar and quartz. The voids are partially filled by a boxwork aggregate of fine, white, granular material which disaggregates between the teeth to a pasty aggregate of clay sized material with abundant silt. On a fresh break, however, the material has considerable cohesion and maintains its porous boxwork texture.

MICROSCOPIC CHARACTERISTICS

The thin section shows a wider range of grain size than the hand specimen would indicate. The slide is dominated by large subhedral to anhedral blocky feldspars and large rounded to irregular quartz grains, but in addition there are numerous patches of silt sized materials in two occurrences. First there are irregular patches of coarse silt to fine sand sized material, dominantly quartz but with some recognizable microcline and zircon grains. These grains are imbedded in abundant opaque material and are associated with extensive iron staining. The second occurrence is the megascopically recognizable fine grained interstitial material. Most of this material has been lost in grinding the thin section but thin rims of very finely granular rhombohedral carbonate were left in some of the cavities.

Quartz appears as clear anhedra with abundant inclusions. The crystals are quite angular but tend to be equidimensional. Grain boundaries vary from smooth curved surfaces to highly sutured boundaries. Liquid filled cavities, many with bubbles, are abundant as trains, most as the result of healed fractures. There are at least two generations of fracturing in that one set is iron stained and contains ameboid shaped cavities whereas others lack staining and contain smaller more regularly shaped cavities, some approaching negative crystal shape. Locally quartz has been replaced or penetrated by a fibrous mineral probably in the cummingtonite--grunerite series.

The most important feature of the quartz is the presence of well developed Boehm lines which show up as polysynthetic twin-like patterns when the grain is near extinction. Most grains show only one set of Boehm lines, however some show two sets. The orientation of twenty five sets of lines were measured relative to the long dimension of the thin section and these show a definite preferred orientation as indicated in the accompanying pie diagram (Fig. 1). Undulatory extinction is present in the quartz but is not universal nor markedly developed.

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Manuscript received, November 30, 1973

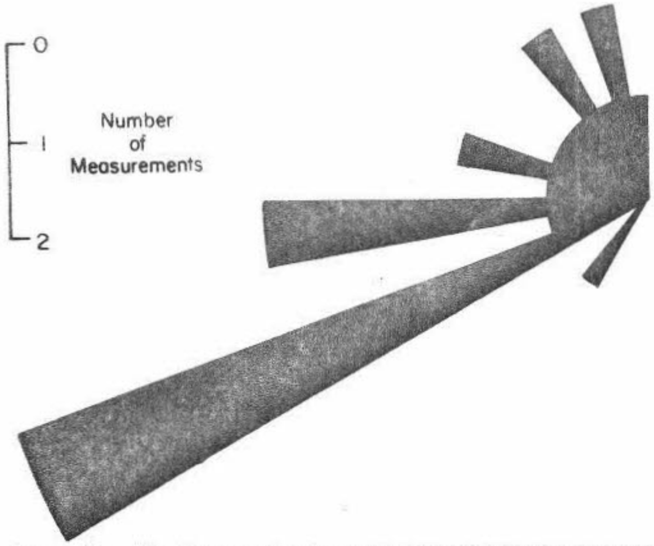

Figure 1. -- Pie diagram showing orientation of Boehm lines in quartz relative to long dimension of unoriented thin-section.

Quartz in the silt patches consists of fine sand to coarse silt sized polygonal single grains. The grains fit together with smooth curved contacts and no suturing of boundaries. Many single grains are outlined by films or trains of granules of opaque minerals and locally opaque materials are more abundant than quartz grains. The large feldspar crystals are anhedral against these silt patches and some of the feldspars contain abundant quartz grains identical to those of the silt patches. Chert is also present in the slide as an apparent replacement of original mica flakes. The largest such flake, approximately 1 mm long in the section, is represented by three patches of chert in which the original cleavage of the mica is recognizable in the chert under plane polarized light.

Microcline, microcline microperthite, and minor oligoclase (An ca. 12 percent) are the feldspars present. Microcline appears as large blocky to irregular rectangular crystals with well developed tartan twinning. Albite twinning is relatively coarse with well defined twin boundaries. Extinction to the albite twinning on 001 cleavage is 15°. Pericline twinning is broader and more diffuse with extinction angles to these twins on 010 cleavages of 5°. Microcline microperthite is identical in its twinning characteristics to microcline but includes irregular patches of plagioclase elongated in the 100 plane. The plagioclase is untwinned in the perthite, but birefringence, relief and extinction angles relative to the surrounding microcline would indicate a sodic oligoclase composition. Plagioclase as a separate phase occurs only rimming nonperthitic microcline. It is in parallel orientation to the adjacent microcline as indicated by the continuity of albite law twins across grain boundaries. Extinction angles indicate a composition near An_{12}. Inclusions in the potassium feldspars are abundant as gas filled cavities, shreddy alteration products, iron staining, and quartz grains. Silt sized quartz grains with random orientation are abundant in the margins of some microperthite crystals particularly in those portions of the feldspars which are close to the silt patches.

The original ore minerals seem to have been pyrite with minor amounts of titaniferous magnetite or ilmenite but now are completely altered to limonite and two grains of leucoxene. The ore minerals are the only primary ferromagnesian mineral recognizable. No pyrite remains in the slide but well developed cubic outlines or aggregates of tiny cubes of limonite are readily recognized. The pyrite was apparently euhedral and authigenic and was most abundant in the residual siltstone patches. Some limonite has crystallized to recognizable goethite crystals showing crossed axial plane dispersion.

A fibrous mineral, tentatively identified as a member of the cummingtonite group, occurs as fibers and tufts. The mineral is colorless but iron stained at the margins of tufts, anisotropic with interference colors to the first order yellow, maximum extinction angle of 17°, and consistently length slow. Most of this material occurs in and along the margins of the silt patches but the fibers penetrate into adjacent quartz and potassium feldspar grains.

Zircon occurs as subhedral to rounded grains and is particularly abundant in the silt patches. One such patch contains thirteen zircons in the section. A rhombohedral carbonate marginal to holes in the slide represents the white granular boxwork in the hand specimen. It is very fine grained and granular. Both indices of refraction are greater than balsam and it does not effervesce with cold HC1, therefore it is tentatively identified as siderite or ankerite.

PETROGENESIS

Evidence for a metamorphic origin of the rock includes: (1) Boehm lines in quartz; (2) character of the alkali feldspars; and (3) presence of the fibrous amphibole. Evidence for the sedimentary character of the rock prior to metamorphism include. (1) fine sand and coarse silt patches; and (2) relict rounded quartz sand grains with secondary enlargement in optical continuity. Also suggestive of a sedimentary origin is the paucity of ferromagnesian silicates and the abundance of limonite after pyrite.

Boehm lines in quartz are the result of strain and are most common in metamorphic rocks. They are rare in igneous rocks unless the rock has been metamorphosed. They may be inherited from a parent metamorphic rock by quartz clasts in sediments, but would show random orientation. The definite preferred orientation of the Boehm lines in the slide is clear evidence of metamorphism.

At a few places in the slide quartz grains are rimmed by a train of opaque grains. Such quartz grains are somewhat smaller than average for the rock and are rounded rather than angular. In one large quartz grain such a rounded train of inclusions is visible within the grain and indicates a sand sized quartz clast with secondary overgrowth probably developed during metamorphism rather than a sedimentary enlargement.

The feldspars appear to be porphyroblasts developed from clastic grains. Microcline partially rimmed by oligoclase and microcline microperthite probably represent two different initial feldspars on the basis of the apparent ratio of volumes of microcline to plagioclase. No statistical measurements were made but the plagioclase content of microperthite appears to be significantly higher than that associated with nonperthitic microcline. The microcline-oligoclase association may have been a single phase of solid solution which underwent exsolution and migration of the plagioclase component during metamorphism. The plagioclase partial rims on microcline are clearly not from an earlier (pre-clastic) origin as they show no abrasion. The fact that the feldspars have grown as porphyroblasts is clearly indicated by the inclusion of silt sized quartz grains at their margins. Chertification of mica flakes was probably the result of the porphyroblastic growth of feldspars requiring additional potassium to upgrade clay minerals.

The silt patches are clearly clastic and cannot be a granulation product. There is some granulation along contacts between the larger crystals and this results in material of a very different appearance from the silt patches. The silt is dominately quartz with minor feldspar and a high concentration of zircon, cemented initially by a highly ferruginous cement. The fibrous amphibole has developed by reaction between the matrix of the silt patches and quartz. The high iron content of the matrix suggests a member of the cummingtonite-grunerite series and thus suggests siderite or ankerite in the original matrix. Optically the amphibole fits into the tremolite-actinolite series which would suggest initial dolomite. In either case the amphibole is of metamorphic origin.

The rock, thus, is metasedimentary and developed from an arkose. The arkose was derived from a simple granitic terrane, was moderately to poorly sorted, and accumulated in a reducing environment. These conclusions are based on the simple accessory mineral assemblage of zircon and possibly cassiterite, the coarse silt to medium sand size of recognizable clasts, and the abundance of pyrite. Metamorphism was probably into the lower amphibolite facies.