Anomalous textures in porphyritic granite of Andhra Pradesh (India)

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Abstract: Apparently perthitic textures of microcline phenocrysts in this rock are not due to exsolution but to deformation. Microscopic fracture planes show no offset, however, and are restricted to feldspar crystals, i.e. absent in quartz. A hypothesis of depth formation is presented, and possible shock origin discussed.

This paper addresses an anomalous geologic feature and it does so in an unusual way, without the orientation and distribution information that one would expect in a geologic treatise. My observations began with granite countertops; some of those from Andhra Pradesh province of India displayed a feature inexplicable in terms of normal petrologic evolution. Nevertheless some progress has been made with petrographic description of the feature, relating it to crystallographic information and the scanty descriptions on the regional geology. Here I describe the anomalous texture of the porphyritic granites of the Karimnagar-Warangal district of northern Andhra Pradesh, astride the Godavari River. My dissemination of a progress report in this form is intended to attract the attention of geologists with access to better analytical equipment, more information on the regional geology, and/or analogous textures.

Regional setting

The quarries of porphyritic granite trend NW-SE (Department of Mines and Geology 2015a) from Karimnagar to Warangal, a distance of about 80 km. These granites, formerly assigned to the Archaean, are now known to be Early Proterozoic (Singh 2004). The country rocks are variously described as granulites including khondalites and charnockites (Ali and Srivastava 1966, Sriramadas 1967), or as gneissic supracrustal rocks showing a variety of high-grade metamorphic assemblages (Singh 2004, Geological Survey of India 2005). The textures of these country rocks have not as yet been described. Diabasic (dolerite) dikes that cut the porphyritic granites are also quarried in this district, and it would be quite interesting to examine these in equivalent detail.

Lamellae orientation

The potassium feldspar crystals in these porphyritic granites have been thought to be perthitic (Sriramadas 1967), i.e. containing lamellae of plagioclase feldspar exsolved from an originally homogenous potassium-sodium feldspar formed at high temperature. Perthitic lamellae typically segregate as such feldspars cool (e.g. the classic paper of Tuttle and Bowen 1958). Indeed the lamellae within the potassium feldspar phenocrysts in the porphyritic granites of Karimnagar and Warangal do look like ordinary perthite, i.e. they form parallel cloudy wisps of lighter-colored material.

However, true exsolved perthite forms in definite crystallographic planes within the host crystal (Wright and Stewart, 1968; Smith and Brown, 1988). By far the most common plane of such exsolution is the so-called Murchison plane, i.e. (601) in relation to the three crystallographic axes (e.g. Lee et al. 1995). Thus the perthitic lamellae orientation is locked into host crystal orientation, and differently oriented host crystals will have different lamellae orientations.

This is emphatically not the case in the porphyritic granites of Karimnagar and Warangal; the orientation of lamellae there is not that of exsolved perthite. Instead the lamellae in potassium feldspar of these granites are nearly parallel across the entire rock, regardless of feldspar crystal orientation (fig. 1). Lamellae orientation varies by no more than 15 degrees between crystals across polished slabs of rock as large as 3x3 m. The orientation of lamellae in potassium feldspar is thus geometrically analogous to cleavage in metamorphic rocks.

Whole-rock petrography

My petrographic examination of the porphyritic granites of the Karimnagar-Warangal district is based on a thin section of granite from Warangal (trade named "English Brown"), chosen because of internal color contrasts that accentuate the texture (fig. 1). Otherwise my examination was with hand lens of many polished slabs including darker "Tan Brown" of Karimnagar.

The most prominent mineral phase of the porphyritic granite of the district, in both hand-specimen and microscopic view, is microcline forming euhedral tabular crystals about 2 cm in length, brownish pink in hand specimen (fig. 1). Lesser plagioclase (ca. 15%) is subhedral and green-gray; quartz (ca. 10%) is interstitial and bluish-gray. Mafic domains (ca. 15%) consist of orange-to-brown biotite and green clinopyroxene (fig. 2). Sphene, opaque oxide, apatite, and zircon are present (cf. Singh 2004). Myrmekite locally separates quartz and feldspar. The plagioclase is ca. oligoclase based on index of refraction and albite-twin extinction, and some has anorthoclase-like tartan twins around its rims. The microcline is compositionally homogenous, with no visible exsolution lamellae.

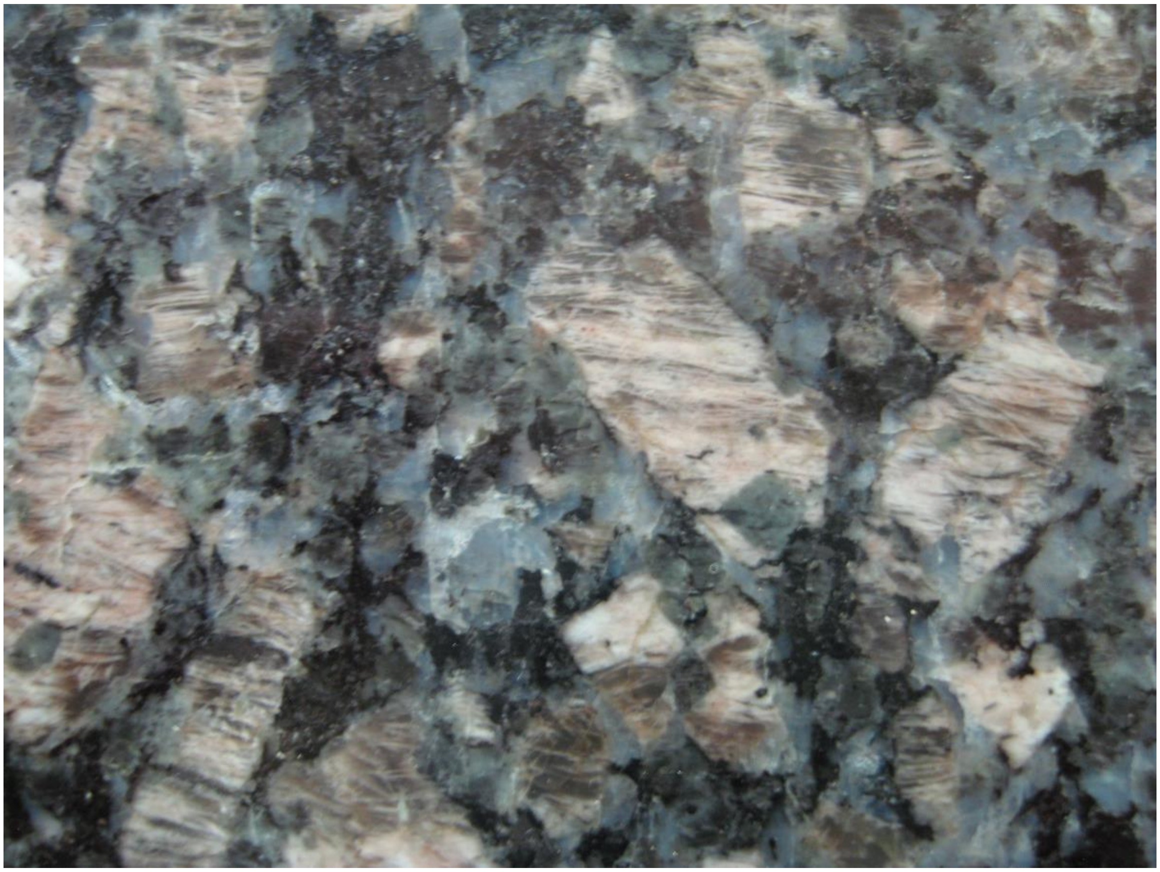

Figure 1. Polished slab of porphyritic granite from Warangal. Large euhedral pinkish prisms are microcline (note subhorizontal texture within each, regardless of orientation, the subject of this paper). Bluish gray mineral is quartz; dark material is mostly biotite and clinopyroxene. Field of view 6 cm.

Figure 2. Cross-polarized view of rock of fig. 1, showing fractures ca. vertical. Microcline top center, plagioclase lower left and right, quartz and biotite interstitial. Field of view 10 mm.

Thus the perthitic look corresponds not to exsolution lamellae, but instead to some sort of fracturing in parallel arrays (fig. 3a). These fractures, though, are apparently confined to feldspar crystals, and are more pronounced in microcline crystals than in plagioclase, where fracture orientation may vary more than 15 degrees. Quartz while typically undulose is not sutured, and biotite-cpx-opaq domains are not visibly fractured. Where the fractures in feldspar reach a feldspar-crystal edge, they disappear into quartz, biotite, pyroxene, and other mineral phases, none of which show these or similar features, but reappear along trend at the next feldspar crystal.

Figure 3a. Plane-polarized view of microcline with fractures oriented NW. Field of view 1.0 mm.

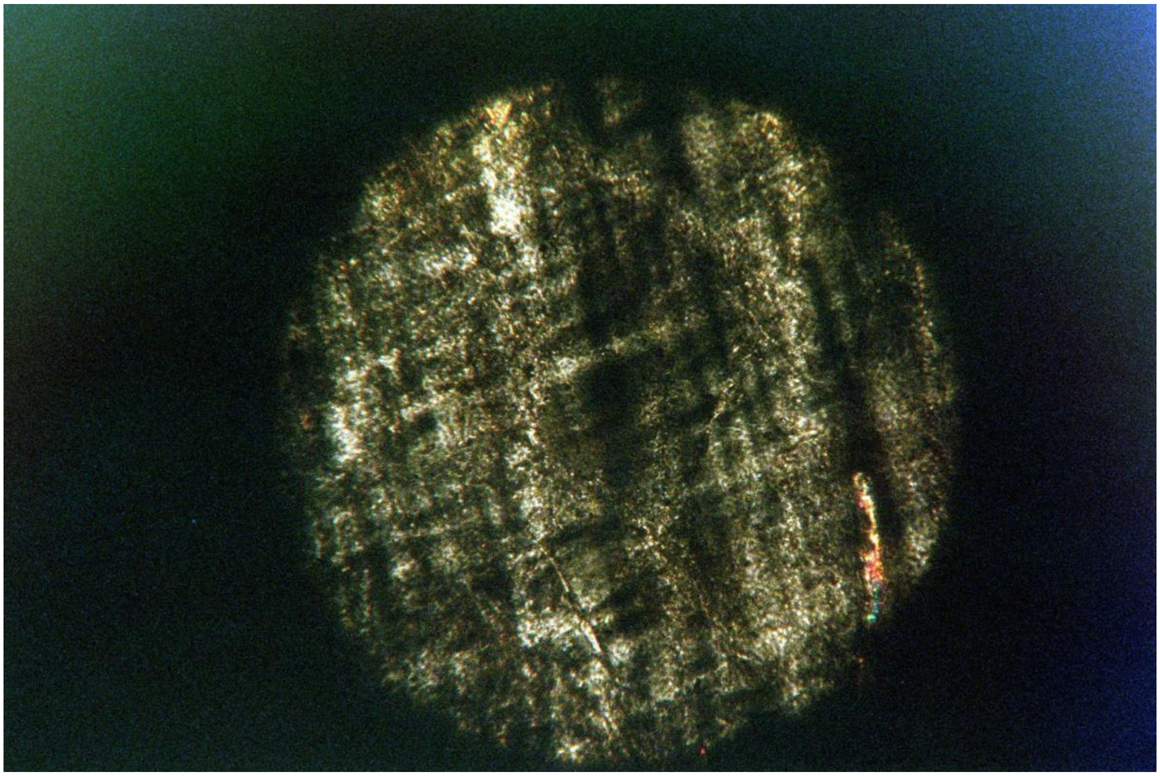

Figure 3b. Cross-polarized view of fig. 3a in same orientation. Note twin planes not offset. Upper fracture contains some birefringent material.

Fracture description

The fractures themselves vary in spacing, and it appears that the perthite-looking lamellae correspond to greater density of parallel fractures in compositionally homogeneous microcline, the light-colored cloudy domains having more fractures. Remarkably, the fractures do not offset either set of twins in microcline. (fig. 3b).

Individual fractures consist of a zone 0.0x mm wide defined by trains partly of isotropic domains, mostly equant, of no more than 5 microns diameter. Some of this isotropic material shows index of refraction less than that of its microcline host; this may include voids. No sericite, chlorite, or epidote low-grade alteration products were detected along the fracture planes, though some minute birefringent grains may be carbonate rhombs. Another minute phase in the fracture planes is prismatic, brown, high-relief, and high-birefringent. A complete description of the fracture planes awaits better equipment.

Exploring the nature of deformation

If all the mineral phases of the porphyritic granites shared the same features as the feldspars in the same orientation, one would not question a deformational origin, though the resemblance to perthite would still be of interest. The extent of the anomalous features in feldspar, apparently coming from several quarries potentially ca. 80 km or more apart is consistent with such a deformational origin, but it would be important to establish the orientation of the fractures over this region as well as their possible occurrence in country rocks of the porphyritic granite.

The lack of deformation features in quartz that correspond with those in feldspar remains puzzling, however. I suggest that the absence of fractures in quartz may be most usefully addressed as a function of the relative ductility thresholds of feldspar (ca. 450 degrees C.) and quartz (ca. 300 degrees C.). Undulose quartz as in the study area may have passed its lower threshold. Feldspars of the study area, however, show no ductility whatsoever and have presumably not passed their higher threshold. Considerable depth regions of the earth's crust (commonly between 10 and 15 km) will preserve deformational features in feldspar but not quartz, analogous to their behaviors in semi-ductile mylonites (e.g. Scholz 1988). Certainly the geologic history of the study area includes far greater depths.

Fracture planes that lack even microscopic offsets might suggest shock metamorphism, and certain features described here show some resemblance to shock features described in quartz. However, some criteria for impact features established by French and Koeberl (2010) have not been met, in part as such criteria for feldspar are not well established. If my hypothesis for the depth of formation of the fractures proves correct, the fractures would have formed far below the impacted surface.

Invitation

My purpose in sending out this information, preliminary as it seems, is to gather comments and suggestions. I would like to involve regional geologists more familiar with these rocks, and/or better-equipped analysts, in whatever next steps are indicated.

References

Ali, H., and Srivastava, K.K., 1966, Geology of the Yerabali area, Karimnagar-Warangal districts, Andhra Pradesh: Records of the Geological Survey of India, v. 94, p. 190-210.

Department of Mines and Geology, Andhra Pradesh, 2015a, Geology and mineral resources of Karimnagar district, Andhra Pradesh: web-graphix.in/apmines

Department of Mines and Geology, Andhra Pradesh, 2015b, Geology and mineral resources of Warangal district, Andhra Pradesh: web-graphix.in/apmines

French, B. M., and Koeberl, C. 2010, The convincing identification of terrestrial meteorite impact structures: what works, what doesn't and why: Earth Science Reviews v. 98 p. 123-170.

Geological Survey of India, 2005, Geological and mineral map of Andhra Pradesh

Lee, M. R., Waldron, K. A., and Parsons, I., 1995, Exsolution and alteration microtextures in alkali feldspar phenocrysts from the Shap granite: Mineralogical Magazine v. 59, p. 63-78

Scholz, C. H., 1988, The brittle-ductile transition and the depth of seismic faulting: Geol. Rundschau, v. 77, p. 319-328.

Singh, Y., 2004, Zr, Hf, U. Th and REE-fertile Lower Protoerozoic potassic granite from parts of Andhra Pradesh, south India: Acta Geologica Sinica v. 78, 921-930.

Smith, J. V., and Brown, W. L., 1988, The Feldspar Minerals v. 1: Crystal structure and physical properties: Springer

Sriramadas, A., 1967, Geology of eastern Ghats in Andhra Pradesh: Proceedings of the Indian Academy of Sciences v. 66, p. 200-205.

Tuttle, O. F., and Bowen, N. L., 1958, Origin of granite in the light of experimental studies in the system NaAlSi3O8-KAlSi3O8-SiO2-H2O: Geological Society of America Memoir 74

Wright, T. L., and Stewart, D. B., 1968, X-ray and optical study of alkali feldspar: American Mineralogist v. 53, p. 38-87