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PETROLOGY AND STRUCTURE OF PRECAMBRIAN ROCKS OF THE PEDERNAL HILLS, NEW MEXICO

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INTRODUCTION

The Pedernal Hills, in Torrance County, New Mexico are formed on the principal exposures of Precambrian rocks in the area of this year's field conference. The site of the present-day Pedernal Hills was part of a larger positive element that was shedding clastic debris into adjacent basins during the late Paleozoic (Fallis, 1958). Therefore, a thorough understanding of upper Paleozoic sedimentation in this region is dependent in part on knowledge of the Precambrian rocks that supplied the clastic components.

This report is based upon reconnaissance work by Woodward in 1966 and a more detailed thesis project by Gonzales (1968) under the supervision of Woodward.

Five principal Precambrian rock units in the Pedernal Hills are granitic gneiss, metaquartzite, a heterogeneous but largely schistose unit, a granitic intrusive unit, and cataclasite. Age relations of the first three units cannot be definitely stated, but the available evidence suggests that the metaquartzite is older than the heterogeneous unit. The granitic gneiss may be either younger or older than the metaquartzite and heterogeneous unit. The granitic intrusive unit is younger than the three units noted first, and the cataclasite, composed of intensely sheared granite and the older metamorphic rocks, is the youngest Precambrian unit.

Each of the units noted above consists of several lithologic types, but the unit is referred to by the dominant lithology. These units are described below in their suggested chronologic order from oldest to youngest, and shown on Figure 1.

ROCK UNITS

Metaquartzite

This unit is comprised of three rock types, metaquartzite, quartz-muscovite schist, and quartz-specularite schist. The latter two lithologies are subordinate and form thin interbeds within the more abundant metaquartzite.

The metaquartzite is fine grained, gray to whitish, thin bedded, and forms blocky outcrops. Weak to moderately developed schistosity (S_2) is mostly parallel to compositional layering (S_1) which probably represents bedding. Quartz makes up about 95 percent of the rock, is intensely sutured, and is slightly elongate in the schistosity. Very small plates of muscovite are well aligned in the schistosity and compose about 4 percent of the rock. There are traces of specularite, magnetite, tourmaline, and apatite.

Fine-grained quartz-specularite schist forms layers up to 10 cm thick intercalated with the metaquartzite. Intensely sutured quartz makes up 70-80 percent of the schist. Specularite forms very fine-grained plates that are well aligned and define the schistosity (S_2). The specularite imparts a dark-gray to black color to the rock in hand specimen. Small amounts of muscovite (2-3 percent) and magnetite (2 percent) are present. The schist contains traces of tourmaline, apatite, zircon, and porphyroblastic kyanite. Isoclinal microfolds are common in some specimens.

Quartz-muscovite schist occurs in thin beds that form zones up to 3 m thick within the metaquartzite; this schist is fine grained and silvery to reddish or gray. The schist consists of about 50 percent quartz, 40 percent muscovite, and 9 percent stilpnomelane, magnetite, and chloritized biotite. There are traces of apatite, zircon, tourmaline, and porphyroblastic staurolite. The rock has a well developed schistosity (S_2) marked by parallel mica plates with elongate quartz; the schistosity is parallel to compositional layering (S_1). Isoclinal microfolds are abundant.

The parent rock of the quartz-muscovite schist was a shaly sediment. The quartz-specularite schist is a variety of iron-formation which is commonly thought to have formed by chemical precipitation of Fe_2O_3 and SiO_2 in seasonal layers (James, 1955). Barker (1968), however, has suggested that hematite-bearing metaquartzites in northern New Mexico were derived by regional metamorphism of magnetite-rich black sands in clastic quartzose sand. The origin of the iron-rich rocks in the Pedernal Hills area is not known, as the intense shearing and recrystallization that occurred during regional metamorphism has destroyed the original sedimentary textures.

The metaquartzite likewise has no original sedimentary textures preserved; it may have been derived from either chemically precipitated SiO_2 with very minor influx of clay during sedimentation or from a very pure quartzose sandstone. The presence of traces of rounded zircon, tourmaline, and apatite suggest a clastic origin for the metaquartzite, but they offer no conclusive proof.

Traces of porphyroblastic staurolite in the quartz-muscovite schist and kyanite in the quartz-specularite schist indicate that regional metamorphism attained the staurolite-almandine subfacies of the almandine amphibolite facies (Winkler, 1965, p. 89).

Heterogeneous Unit

This map unit is composed principally of micaceous phyllitic and schistose rocks, but includes also subordinate augen gneiss, metaquartzite, and nonfoliated rocks such as epidiorite, greenstone, and epidote-amphibolite.

The schist and phyllite are distinguished on the basis of

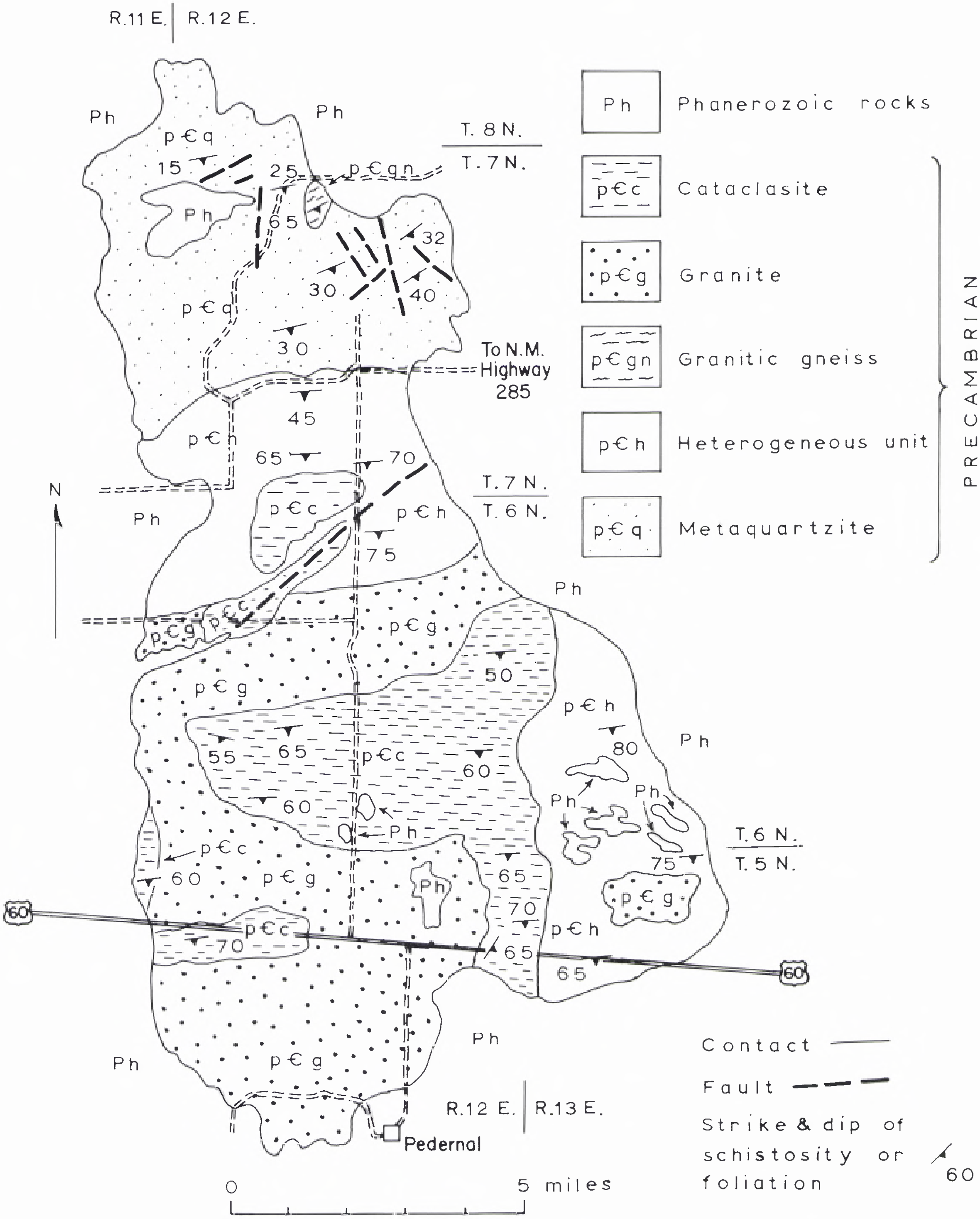

Figure 1. Generalized geologic map showing Precambrian rocks of Pedernal Hills area, Torrance County, New Mexico.

grain size, but both contain similar mineral assemblages, although in different proportions. Both the schist and phyllite are characterized by well developed crystallization schistosity (S_2) that is defined by strongly aligned platy minerals and elongate quartz; S_2 parallels compositional layering (S_1) which probably represents bedding. Lithologies that are present include quartz-muscovite schist, quartz-muscovite-biotite schist, quartz-muscovite-chlorite (± epidote) schist, chlorite-muscovite-quartz phyllite, quartz-biotite-epidote schist, and quartz-epidote schist. In addition to the principal minerals, there are minor amounts of apatite, zircon, tourmaline, opaque minerals, feldspar, calcite, and stilpnomelane in many of the specimens.

Colors of the heterogeneous unit range from greenish gray through pinkish to reddish brown. These rocks of the heterogeneous unit were formed by regional synkinematic metamorphism of quartzose and argillaceous sediments that locally were calcareous. The mineral assemblages indicate that the grade of metamorphism reached the middle greenschist facies (Winkler, 1965, p. 79).

Greenstone is dark green to dark gray, fine grained, and appears nonfoliated in hand specimen. Thin sections reveal a very weak alignment of minerals. The rock is composed of actinolitic hornblende (70 percent), epidote minerals (10 percent), interstitial quartz (as much as 15 percent), and minor amounts of magnetite, plagioclase, biotite, chlorite, and stilpnomelane. The greenstone was derived by greenschist facies metamorphism of a basic, fine-grained igneous rock.

Epidiorite consists of fine- to medium-grained hornblende (70 percent), epidote (10 percent), quartz (10 percent), chlorite (5 percent), and minor amounts of biotite, plagioclase, and opaque minerals. The texture suggests that the rock was originally diorite and the present mineral assemblage was formed during metamorphism. The metamorphism may have been a contact effect related to emplacement of the granite.

Epidote-amphibolite is rare and is mostly found in association with the epidiorite. The epidote-amphibolite is fine grained and consists of epidote and clinozoisite (65 percent), actinolitic hornblende (25 percent), and minor amounts of quartz, opaque minerals, and stilpnomelane. This rock was derived from a fine-grained, mafic igneous rock.

Augen gneiss also is rare, and occurs only in the southeastern part of the mapped area, south of U.S. Highway 60 near the contact with the granite. The gneiss is well foliated, fine to medium grained, light gray, and contains pink microcline augen up to 2.0 cm long. It consists of microcline (45 percent), quartz (35 percent), andesine (5 percent), biotite (5 percent), muscovite (5 percent), and small amounts of epidote, apatite, zircon, opaque minerals, tourmaline, and chlorite after biotite. The gneiss may have been derived from a granitic parent rock.

Thin beds of metaquartzite similar to that previously described are intercalated with schist in the northern part of the outcrop area of the heterogeneous unit, and probably were derived from quartzose sand layers.

Granitic Gneiss

The granitic gneiss is the least abundant of the five major map units, as it has a surface exposure of less than 0.5 square mile (Fig. 1). This unit includes many small pegmatite and aplite dikes up to 10 cm wide.

The gneiss is light pink to flesh colored, fine to medium grained, and has a well developed lenticular and undulatory foliation. It is composed of microcline (35 percent), quartz (35 percent), calcic oligoclase (10 percent), and biotite (10 percent), with accessory hornblende and chlorite. There are traces of epidote, magnetite, apatite, sphene, myrmekite, and zircon.

The parent rock of the gneiss may have been either an igneous rock of granitic composition or a pelitic sediment. The high quartz content favors a sedimentary origin, but the outcrop pattern is suggestive of an igneous intrusive body. If the parent was a sediment or an extrusive igneous rock the gneiss may be older than the metaquartzite; if the parent was an intrusive rock the gneiss may have been emplaced after deposition of the metaquartzite, but prior to regional metamorphism. The grade of metamorphism probably reached the almandine amphibolite facies.

Granitic Intrusive Unit

Porphyritic granite makes up about 85 percent of the surface exposure of this unit, alkali granite 10 percent, and quartz monzonite about 5 percent. Minor amounts of quartz diorite occur where the magma assimilated basic country rock.

The porphyritic granite is light pink, fine to coarse grained, and typically massive, although a faint foliation occurs locally. The rock consists of pink microcline (45 percent) that commonly forms phenocrysts up to 1.0 cm across, quartz (20 percent), plagioclase (An_{27-34}, 15 percent), minor amounts of biotite, and traces of epidote, apatite, zircon, tourmaline, sphene, and stilpnomelane.

Alkali granite occurs at the contact between the intrusive unit and the schist to the north. The alkali granite is similar to the porphyritic granite except that the plagioclase is albite (An_7) rather than oligoclase and andesine as in the porphyritic granite.

Quartz monzonite is present in the northwestern part of the intrusive unit and appears to grade into the porphyritic granite. The quartz monzonite contains nearly equal amounts of microcline and plagioclase (An_{28-32}) along with 20 percent quartz, and about 5 percent biotite.

Quartz diorite occurs in the southwestern part of the intrusive unit where inclusions of amphibole-rich country rock are abundant. The quartz diorite is composed of plagioclase, quartz, and hornblende.

Numerous pegmatite and aplite dikes up to 20 cm wide cut the other rocks comprising the intrusive unit.

The intrusive unit was emplaced after regional metamorphism of the metaquartzite, heterogeneous unit, and granitic gneiss. The massive texture of the porphyritic granite and the local presence of a strongly porphyritic border facies indicates that the intense shearing and recrystallization that occurred during regional metamorphism had ceased prior to emplacement of the intrusive unit.

Numerous, randomly oriented inclusions of metamorphic country rock suggest that magmatic stoping may have been an important mechanism of emplacement. The quartz dioritic facies with its abundant mafic inclusions suggests that the granitic magma was contaminated by assimilation of the mafic rock; this is further supported by the presence of actinolitic hornblende in the quartz diorite and the inclusions. The evidence for forcible injection and dilation is rather tenuous, as the contact with the surrounding host rocks is mostly covered by Phanerozoic rocks (Fig. 1). Intensely sheared granite and adjacent country rock (cataclasite) may indicate that there was late pushing of the crystallized upper part of the intrusion by magma at depth.

Cataclasite

The cataclasite consists of very fine-grained, intensely sheared granite and older country rock that underwent only minor recrystallization. Most of the cataclasite is dark gray, but it may be light gray and pink. Porphyroclasts of quartz and feldspar up to 10 mm long are set in a matrix of finely ground quartz and feldspar and accessory minerals. The shearing has resulted in weak to strong foliation. The minerals present in a given specimen are those that were present in the parent rock, as there have been no reactions to produce new minerals during the shearing.

METAMORPHISM

There is evidence of three episodes of metamorphism, in chronological order, (1) regional synkinematic metamorphism of the metaquartzite, the rocks of the heterogeneous unit, and the granitic gneiss, (2) contact metamorphism adjacent to the granite intrusion, and (3) intense shearing of granite and older rocks to produce the cataclasite.

The regional metamorphism was characterized by simultaneous penetrative deformation (shearing) and recrystallization. The grade of metamorphism ranges from greenschist facies in some of the rocks of the heterogeneous unit to almandine amphibolite facies in the metaquartzite. The granitic gneiss probably reached the almandine amphibolite facies also.

Contact metamorphism adjacent to the granite intrusion was probably of hornblende hornfels facies. This is suggested by the presence of dark-green hornblende in the epidiorite that occurs near the contact.

The last episode of metamorphism was dynamic shearing with only minor recrystallization to produce the cataclasite from the granite and older rocks.

STRUCTURE

The structures discussed here appear to be of Precambrian age, as they occur entirely within the igneous and metamorphic rocks and have not affected the overlying Paleozoic rocks. Other structures, of Phanerozoic age, are not discussed here.

The oldest structures are isoclinal, nearly recumbent, small-scale folds in the metaquartzite and quartz-specularite schist. These folds have wave lengths of only a few inches and formed by shearing during regional metamorphism. The limbs parallel the schistosity and compositional layering of the schist, and the noses are transected by elongate minerals parallel to the axial surfaces of the folds. Thus, the shear folding occurred contemporaneously with regional metamorphism.

Tightly compressed but open folds having wave lengths up to several inches occur in phyllite of the heterogeneous unit. Axes of these folds parallel the strike of the schistosity.

A few larger, open, upright folds having wave lengths up to 500 feet are present in the central part of the exposure of the metaquartzite.

Several high-angle faults having a few feet of stratigraphic separation occur in the metaquartzite. These faults are marked by recrystallized quartzite breccia zones up to a foot in width. Another high-angle fault of unknown displacement occurs in the rocks of the heterogeneous unit.

Shears which produced the cataclasite trend easterly and dip steeply to the south. The displacement caused by these distributed shears may be large, but cannot be determined from the available evidence.

Three prominent joint sets in the granite and cataclasite trend N. 80° E., N. 30° E., and N. 20° W. The metaquartzite has a joint set that trends north and is vertical and another set parallel to foliation.

REFERENCES

Barker, Fred, 1968, Occurrence and genesis of hematite in Precambrian clastic rocks in southwestern Colorado and northern New Mexico (abs.): Geol. Soc. America Cord. Mtg., Tucson, April 11-13, 1968, p. 33.

Fallis, J. F., 1958, Geology of the Pedernal Hills area, Torrance County, New Mexico: M.S. thesis, Univ. New Mex., 63 p.

Gonzalez, R. A., 1968, Petrography and structure of the Pedernal Hills, Torrance County, New Mexico: M.S. thesis, Univ. New Mex., 78 p.

James, H. L., 1955, Zones of regional metamorphism in the Precambrian of northern Michigan: Geol. Soc. America Bull., v. 66, p. 1455-1488.

Winkler, H. G. F., 1965, Petrogenesis of metamorphic rocks: Springer-Verlag, New York, 220 p.

Woodward, L. A., and J. P. Fitzsimmons, 1967, Precambrian banded iron-formation, Pedernal Peak, Torrance County, New Mexico (abs.): N. Mex. Geol. Soc. 18th Ann. Field Conf. Guidebook, p. 228.

Woodward, L. A., 1968, Metamorphic and igneous rocks of Pedernal Hills area, Torrance County, New Mexico (abs.): Geol. Soc. America Cord. Mtg., Tucson, April 11-13, 1968, p. 130-131.