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Uplift – Cross Joints
in Plutons

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Geology of Elk City Mining District, Idaho

With Special Reference to the Structural Setting of the Veins

By P. J. Shenon and J. C. Reed
SALT LAKE CITY, UTAH

DISCUSSION OF THIS PAPER IS INVITED. Discussion in writing may be sent to the Editor, American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York, N. Y. Unless special arrangement is made, the discussion of this paper will close Nov. 1, 1934. Any discussion offered thereafter should preferably be in the form of a new paper.

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Geology of Elk City Mining District, Idaho*

With Special Reference to the Structural Setting of the Veins

By P. J. Shenon† and J. C. Reed, Salt Lake City, Utah

(New York Meeting, February, 1933)

3. Elk City District, Idaho. From Geology of Elk City Mining District, by P.J. Shenon and J.C.Reed, AIME Tech.Pub.562,1934.(N.Y.Meeting,Feb,,'33).

Metamorphic rocks surround a body of granodiorite,or at least encircle it on the west,southwest and south. See plan. The following is pieced together from a most disjointed description.

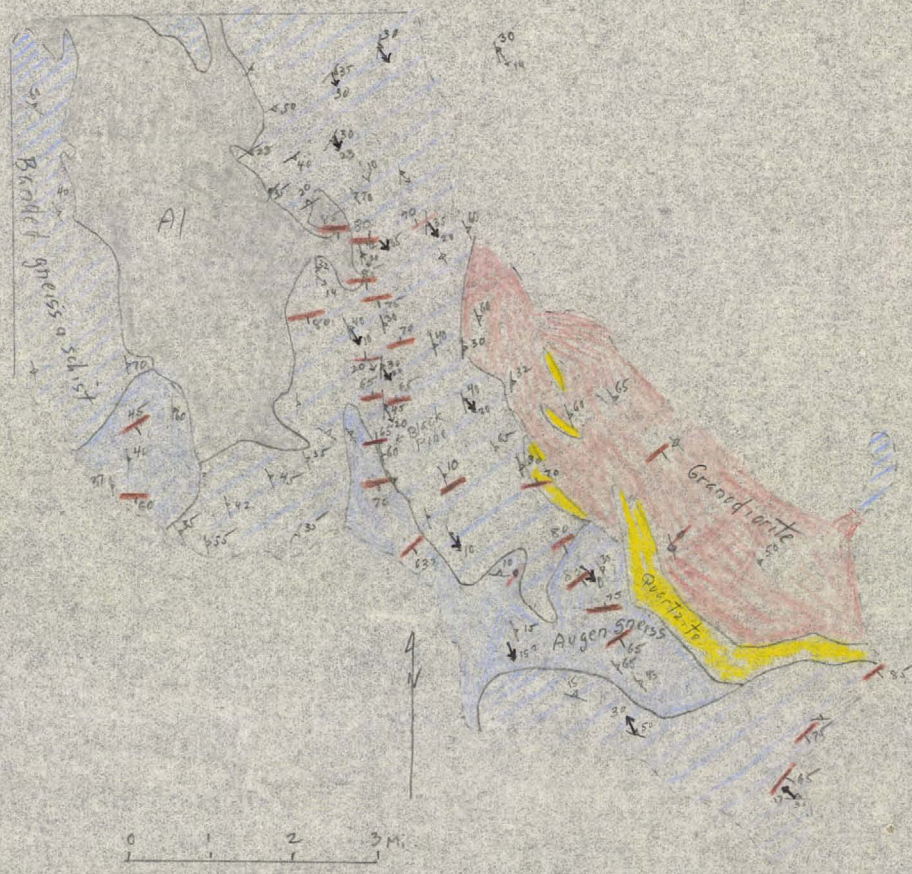
The metamorphics are derivatives of a thick sedimentary series of unknown, possibly Belt age. The quartzite has a rather coarse granular texture,and besides quartz has minor orthoclase,muscovite,biotite,zircon and magnetite. The feldspar is usually in rounded grains along contacts between quartz areas. Hence part of the feldspar,at least,may have been added from magmatic sources. The schists vary from largely quartz-schist to schist rich in feldspar. Biotite and muscovite are abundant. Microcline is rather common in the feldspathic varities impregnated by granitic material. Most of the schists contain apatite and zircon;some carry epidote, sillimanite,tourmaline and garnet.

The banded gneiss, shown on the map as a unit, applies to rocks showing alternate light and dark bands. The proportions of light and dark bands vary greatly,from schistose rocks with a few imperfect light bands to gneissic granodiorite with a few irregular dark bands. The poorly banded schistose gneisses carry principally quartz, biotite and muscovite,with quartz making up over 50% of the rock . The well banded gneisses are mainly oligoclase and quartz. The augen gneiss,also mapped as a unit,differs from banded gneiss because it contains many large microcline crystals and knot-like lenses of aplite.No sharp line can be drawn between augen gneiss and banded gneiss containing a few large microcline crystals on the one hand, and with gneissic granodiorite with large microcline phenocrysts on the other. The chief minerals are oligoclase, microcline ,quartz and biotite,and the microcline appears to have been introduced after the rest,as seems to be the case with many ofthe schists.

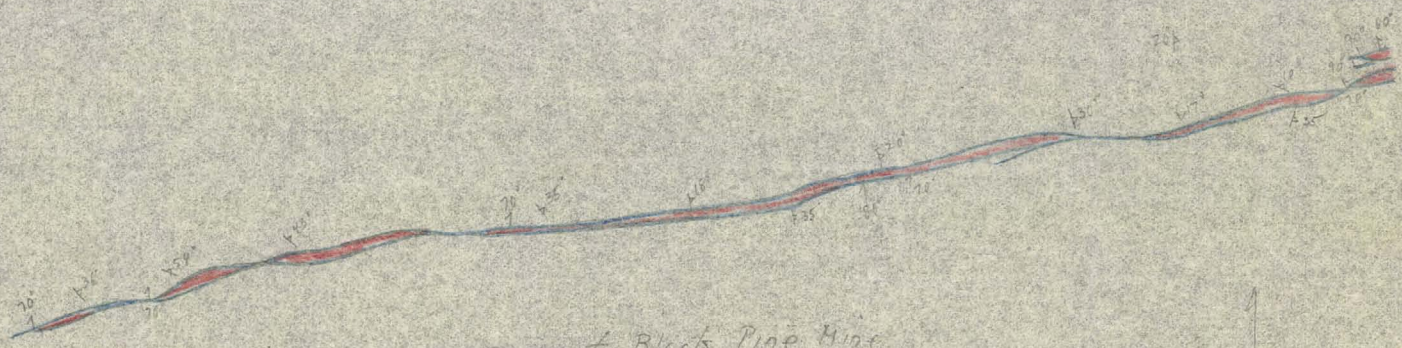
The granodiorite is coarse-grained,decidedly porphyritic; its texture is gneissic near contacts with gneisses. Contacts between granodiorite and gneisses are gradational. The main minerals are oligoclase,quartz,microcline, green hornblende and biotite.

The authors deftly avoid interpretation; this is unfortunate since the thesis of the paper is the structural setting of the veins. However,they say the granodiorite is intrusive into the gneiss,and that the foliation of the granodiorite corresponds to that of the gneiss; also that the augen gneiss probably grades into the banded gneiss along the strike. Also, the planar foliation of the banded gneiss, augen gneiss and schist coincides with the bedding of these rocks. The foliation is parallel to the mapped quartzite bands,representing definite sedimentary layers. This is obviously vague,since they stress the point that the granodiorite, igneous, grades into the gneiss, sedimentary. They speak of varieties of schist impregnated by granitic material . Under Geologic History,they say that the first event was the period of deformation and intense metamorphism. While the metamorphism may have been partly due to folding,the intrusion of the Idaho batholith must have had a profound effect. Since in places granitic rocks clearly cut the folded sediments,part of the deformation of the sediments preceded the intrusion of the batholith,and may represent an early stage of the diastrophism which culiminated in the intrusion and consequent metamorphism.

Reconstructing the picture from these hints,we seem to have an intrusion conforming to sediments dipping rather steeply NE, i.e. laccolithic in character. The metamorphism,intense in the sediments and occurring along the contact with the granodiorite,in the latter,is presumably due to the intrusion; but granitic material,given off by the intrusion,invaded the schists after they had become schists,forming injection gneiss, etc.



ELK CITY DISTRICT



Part of Black Pine Mine

Fig 2

0 10'

Quartz Veins.- The most productive veins (gold-quartz) have been found in gneiss and schist, and in a zone less than two miles wide adjacent to the granodiorite contact, although veins occur in all the formations of the bedrock series. Widths to 20'; length from a few feet to at least 300'. The quartz occurs as a series of slightly curved lenses separated by a barren fault, and the lenses are separated from the wall rocks by gouge. Hypogene minerals are pyrite,blende,chalcopyrite, tetrahedrite and gold. The ore minerals tend to concentrate in shoots, although they are distributed to some extent throughout the veins. Some sulphides and gold occur in a narrow zone of hydrothermal alteration next the veins. The alteration consists of calcite, quartz and sericite along fractures and as irregular patches.

Structure.- Most of the veins cut the strikes of the foliation (hence the strikes of the original bedding) at roughly 90°. They also lie normal to a linear element in the plane of the foliation. (See plan). The granodiorite contact is concave toward the NE; so are the outcrops of the sedimentaries; therefore the veins appear to radiate from a point NE of the mapped area. Mostly the foliation dips east toward the concave side of the trend lines. The foliation ofthe intrusive granodiorite seems to correspond with that in the adjacent intruded gneiss.

The linear parallelism mentioned consists of a parallel linear arrengement ofthe prismatic minerals lying within any given schistosity plane. This arrengement also occurs in some rocks lacking planar schistosity. This Streckung is in general parallel to the axes of the minor folds (which are numerous). H.Cloos recognizes a right- angle relationship between this stretching and a set of Q or cross joints. Cloos refers the stretching in wall rocks to analogous movements in them at the time of emplacement of the adjacent intrusive mass. Accordingly, the stretching in the wall rocks and that in the intrusive,if the latter came in under sufficient pressure to deform its walls, shouldbe concordant.

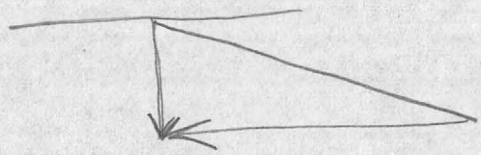
As shown on the map, the stretching defines a NE-trending syncline. Also, the quartz veins have the relation to the stretching that Cloos's Q joints have, except that instead of 90°,the angle is closer to 70°.

Note that the most productive veins strike across the schistosity at nearly a right angle. This is common in other districts, while fractures making small angles with the schistosity are commonly unimportant, and at Elk City, too.no commercial veins parallel the foliation.

The quartz was well fractured before introduction of the sulphides and gold. Zones of more intense fracturing fomom ore shoots. The mineralogical similarity of the ore from all veins hints that all ore minerals came in at the same time, therefore that the intermineralization movements occured throughout the area at the same time. The plan of part of the Black Pine mine suggests that here, at least,such shattering was not simple squeezing open of the fissure (which ,in fact,might not have shattered the quartz),but a shearing movement, north side west, along the fissure.

The tendency for the stretching to be parallel to the granodiorite contact, and of the veins to be normal to it,together with the foliation, parallel to the ancient bedding,being parallel to the contact,points to the foliation being a result of direct squeeze of the granodiorite on its wall rocks,with the direction of elongation or easiest relief being upwards, to the northwest,at moderate angles,in the central and northern part of the district, and upwards to the SE,at similar angles, in the southern part.

The foliation in the granodiorite may be flow-lines. . It is also pos-

sible that regional compression, acting from the NE, shoved the granodiorite, convex to the SW, against the sediments. The massive granodiorite transmitted this stress in directions normal to its SW border. It is even possible that pressure from the SE shoved the sediments against the granodiorite, which acted as a butress and caused flow of the sediments NW and SE along the contact, with gash joints normal to this flow. This might explain the foliation in the granodiorite as true foliation rather than flow-lines. Naturally the stretching wouldbe most intense next this supposed buttress, hence these gash veins there.

Inasmuch as these events appear to be closely linked in time with the intrusion of the Idaho batholith, the stresses that produced the fracture pattern may be ascribed to diastrophism connected with intrusion. It seems far-fetched to suppose that such soft rocks as schist could transmit stress from a far distance up against the granodiorite. It seems most likely that the granodiorite mass mapped caused the schistosity and gneissic structure in the sediments, as well as the stretching and the tension fractures. The gneissic structure around the border of the granodiorite, and within the latter, may well be due to the fact that the shell of the intrusive had solidified, or nearly solidified, while the interior was still markedly not solid, viscous or more liquid. The shell had more or less the characteristics of the soft sediments, hence was metamorphised like them. This notion would accord with the fact that the sediments were apparently impregnated with granitic material after they had become schistose (the hints about injection gneiss etc. in the paper). The granitic material could well have escaped from the still molten core of the massive, through joints developed in the shell. One of these is shown on the plan, and since the granodiorite grades through gneiss to gneissic sediments, probably a number of the veins shown adjoining the granodiorite, in the "banded gneiss", are really in the shell. This conception, besides explaining the injection of granitic material into the schist, would also explain the vague nature of the granodiorite contact, since the great bulk of the squeezed-out granitic material would probably be deposited immediately without the shell, in the nearest sediments. It is notable that the augen gneiss, representing for the most part material with a maximum of injected grantic stuff, occurs next the granodiorite in the trough of the "syncline" delineated by the lines of stretching. If a marked area of weakness had occurred here, the stretching would have extended markedly into this area; a direction of stretching may be defined as a line, more or less perpendicular to a compressive force, and connecting two points or places of low resistance. One such point would be the supposed area of low resistance marked by the development of the augen gneiss; there should be two others, one to the NW, the other to the SE, of that area, each close to the NW trending granodiorite contact. The locations of these other weak areas would be determined much as the location of where a thrust comes out on the surface, i.e. the place ~~in a xxxxxx~~ is determined by the angle or dip of the thrust, and this angle is a resultant of the vertical pressure due to the weight of the cover and the horizontal stress producing the thrust.