Magmatic Source of Idaho Ores

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ABSTRACT: Except for local granitization as an early intense phase of wall-rock alteration, the Idaho ore deposits show no relation whatsoever to large-scale granitization such as is involved in batholithic emplacements. The Idaho batholith, a notable product of recrystallization-replacement processes, has been a producer of pegmatites and aplites but not of ores. As the batholith is believed to have been conceived of crustal materials, it is thought to be incapable of producing appreciable amounts of ore.

The ore deposits on the other hand show a very close association with igneous activity and orthomagmatic rocks and appear to have had their source in the more basic material beneath the granitic crustal shell.

Introduction

With growing recognition that granitic rock may result from recrystallization-replacement or granitization processes, it is pertinent to determine what part, if any, granitization processes may have had in the formation of ore deposits which so long have been regarded as the products of magmas. The relation of ore mineralization to granitization is one that has interested the writer ever since the early thirties when he recognized the part that granitization had played in the emplacement of the Cassia batholith (Anderson, 1934) and later still in the Nelson (Anderson, 1940) and Idaho (Anderson and Hammerand, 1940) batholiths. Inasmuch as granitization has had a role in the emplacement of these batholithic masses, it would seem logical to expect that granitization too may have had a part in ore mineralization. Consequently, special attention was given to the association of the ores with the Idaho batholith which so long had been regarded as the most important "ore bringer" in the state.

Ore Mineralization and the Idaho Batholith

As study of the relationship between the ores and the batholith progressed, it became increasingly clear that the batholith and hence granitization processes had had nothing to do with the metallization. Doubt of an ore-batholith association came when the writer was unable to reconcile shallow (epithermal) ore characteristics with a deep-seated batholithic environment (Anderson, 1939). The evidence indicated that ore deposits supposedly related to the batholith had been formed close to the surface and hence after most of the cover had been stripped from the batholith. This situation necessitates a long-time interval between the emplacement of the batholith and the mineralization, an interval too great to permit a genetic relationship. It was noted too that the deposits were localized along zones of structural weakness which had come into existence during the Laramide orogeny, some time after the emplacement of the batholith (Anderson, 1948*a*). These zones were also occupied by intrusions recognized as of early Tertiary age; significantly, the ore proved to have been introduced during the closing stages of this igneous activity, just ahead of the lamprophyres. The deposits supposedly related to the batholith were actually products of early Tertiary magmas. The batholith was thus proved to be barren of related mineral deposits, except pegmatites.

The relation of the ore deposits to early Tertiary magmas has been given considerable attention in a recent paper (Anderson, 1951), but it may not be amiss to review the relationships as expressed in the Coeur d'Alene district.

Genetic Relations of the Coeur d'Alene Ores

The close association of the ore deposits with igneous rocks in the Coeur d'Alene district is a matter of record, but opinions have differed as to the age of the igneous rocks and hence the age of the ore deposits. Earlier writers on Coeur d'Alene geology have assumed that the monzonitic and other igneous rocks were outliers of the Idaho batholith and so have related the ore deposits indirectly to the batholith. The writer has not shared this assumption. He has found no petrographic resemblance between the monzonitic and syenitic rocks of the Coeur d'Alene district and the quartz dioritic, granodioritic, and quartz monzonitic rocks that compose the Idaho batholith. He has on the other hand noted their resemblance to intrusive rocks that cut the batholith elsewhere in the state and which have been regarded there as of early Tertiary age (Anderson, 1939). He has further pointed out the localization of the Coeur d'Alene intrusions along a zone of structural weakness dominated by the Osburn fault which, like the zones of structural weakness that cut the Idaho batholith, came into existance during the Laramide disturbance, locally as a result of shear around the rigid mass of the batholith at the same time the sedimentary strata in the Laramide trough to the east were being deformed by compression (Anderson, 1948*a*). Because of the lack of resemblance of the Coeur d'Alene rock to that of the Idaho batholith and because of the localization of igneous activity along Laramide-formed structures, the writer has inferred an early Tertiary age for the local intrusion and mineralization.

At no place is the relationship between mineralization and igneous activity better expressed than in the eastern part of the Coeur d'Alene district where the ores show a marked zonal distribution about the Gem stock, the "hot center" of the Burke-Mullan area. This stock and others nearby record a complicated endomorphic development which some petrologists might interpret as local granitization. Petrologic studies reveal that the intruding magma had a moderately basic composition and consolidated as a quartz-bearing diorite or norite and that while still hot the rock was transformed into monzonite and syenite by the action of potash-rich emanations from depth (Anderson, 1949). The introduced potash caused widespread replacement of the earlier rock by potash feldspar and where the emanations permeated into the bordering sedimentary rock also replaced that rock by feldspar and changed it to syenite. The changes in the original rock are due to replacement, but the changes are endomorphic and not those ordinarily associated with a granitization process.

Elsewhere in the district, where there had been no pre-heating by igneous intrusion, the potash-rich emanations were directed upward along deeply extending fault zones in relatively cold rocks and because of the lower temperatures, the rocks were sericitized rather than feldspathized. In this way the bleached zones such as that which characterizes the "Dry Belt" came into existance. The sericitization as well as the feldspathization in the case of the monzonitic rocks may be looked upon as an intermediate stage in the mineralization process, with the source of the potash in the deep magma chamber which was the source also of the metallizing fluids.

Through most of the district the ore deposits show a particularly close association with diabasic and lamprophyric dikes, the ores having been introduced after the intrusion of the diabases but before the formation of the lamprophyres. The ores therefore belong late in the magmatic cycle.

Except for the endomorphic transformations, the igneous rocks exposed within the district are chiefly of diabasic and locally noritic or dioritic composition. These rather basic rocks are probably injections of the original or parent deep-seated magma which later differentiated at depth and gave birth to the potassic emanations, the ores, and the lamprophyres. The record of what went on in the deep magma chamber is much more complete in the Wolf Lodge Bay area west of the Coeur d'Alene district, particularly at and near Beauty Bay. There successive injections have brought up magmas that have given rise to bodies of diabase, hornblende-biotite diorite, biotite monzonite, granite porphyry, rhyolite porphyry, porphyritic quartz monzonite, and lamprophyre (Anderson, 1940). These types of rocks are transitional and exemplify the changes that must have taken place in the deep magma chamber during differentiation. As would be expected where there has been so much rock preheating by igneous intrusion, the accompanying metallization shows high-temperature characteristics and the ore deposits contain much arsenopyrite and pyrrhotite.

Possible Relationship of Ore to Granitization

Probably the best case that can be made for a granitization origin of ores is that of the tungsten ores in the Blue Wing district of Lemhi County, Idaho (Anderson, 1948*b*). There the minerals show a striking zonal distribution about an irregular body of granite exposed in the underground workings at the Ima mine. Study of the granite has revealed that it is a granitized quartzite and that its formation is closely tied up with the mineralization process. The granite has been interpreted as a product of an early, intense type of wall-rock alteration, with the ores appearing during the later, somewhat cooler stage. The source of these "granitizing" solutions and the ores is believed to be a deeper magma of early Tertiary age.

Feldspar-impregnated wall rock has been observed in the nearby Dome district (Anderson, 1947) and there also interpreted as a product of wall-rock alteration and formed in advance of the metallization. Such feldspathic alteration should not be surprising. Mineralizing fluids in general are known to carry potassium, lime, magnesium, aluminium, iron, etc., and under moderate conditions of temperature are known to enter the walls and cause formation of sericite and other minerals. Indeed, sericitization is one of the most common processes of wall-rock alteration. Sericite, however, does not form at relatively high temperatures but feldspar does, and, as the fluids contain the substances needed to make feldspar, it should not be surprising that the wall-rock alteration is reflected in feldspathization or local "granitization," when temperatures are sufficiently high.

Conclusions

The writer has had occasion before (1942) (Anderson, 1942) to express his views on the granite and ore problem and has pointed out that large-scale granitization in Idaho was not accompanied by ore formation. Such granitization as might be linked with mineralization appears as an early phase of rather high-temperature wall-rock alteration with the source of the granitizing and ore-forming fluids in a deeper magma body. The absence of ore bodies about the batholithic masses was interpreted to mean that emanations even from deep sources, though capable of transforming rock, were apparently incapable of forming ore.

Since then the writer has reaffirmed his view (Anderson, 1951) that the Idaho batholith, which shows much evidence of a granitization or replacement origin, has produced nothing more valuable than pegmatites, and that the ores supposedly related to the batholith were definitely related to much younger intrusive magmas. Perhaps the reason that the huge granitized masses of rock are not "ore bringers" is that they are reorganizations of crustal materials which were largely devoid of ore substance, except that added from deeper sources during igneous activity. Only such constituents as are more or less typical of the granitic crust might be expected to be concentrated during the granitization process. Among such constituents would be the light elements which enter into the pegmatites and such relatively rare metals as uranium, tungsten, tin, and molybdenum, all of which in part seem to show some preference for granitic rocks. The metals of pre-existing veins and lodes would probably be dissipated by the granitizing fluids, if compatible with them at all.

The source of the ores of our epigenetic deposits appears to be the magma, and the magma in turn appears to have its origin not in the crustal rocks but in the deeper, more basic zones beneath the granitic shell. Although the preceding discussion has dealt entirely with the older group of ore deposits which have been so generally accepted as products of the Idaho batholith, the association of a younger group of deposits with mid-Tertiary magmas is even better defined and more intimate than the association of the earlier deposits with the early Tertiary magmas (Anderson, 1951). These younger deposits point just as strongly to a deep magmatic source for the ores and accompanying intrusions and bear out the inference that the magma source is below the roots or source region of the batholiths.

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