C. E. Nelson

Volcanic domes and gold mineralization in the Pueblo Viejo district, Dominican Republic

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Abstract Gold mineralization in the Pueblo Viejo district, Dominican Republic, is spatially and temporally related to a series of Early Cretaceous volcanic domes. Separate but overlapping hydrothermal cells, centered on the domes, together deposited more than 40 million oz. of gold, 240 million oz. of silver, 3 million tonnes of zinc, and 0.4 million tonnes of copper. Two principal deposits (Moore and Monte Negro) and a number of smaller deposits (Cumba, Mejita, Upper Mejita, Banco V, Arroyo Hondo I and II) have contributed ore since mining commenced in 1975. New geologic mapping has identified a series of previously unrecognized volcanic domes that vary from andesite to dacite in composition. A dacite porphyry dome intrudes epilastic sediments in the Moore deposit and is surrounded by a baked contact metamorphic aureole. Crumble breccias of mixed epilastic and pyroclastic origin mantle andesite domes in the Monte Negro, Cumba, and Mejita deposits. Epilastic volcanic sediments surrounding each of the domes reflect the composition of the local source rock. Andesite domes of the Monte Negro deposit are surrounded by andesitic volcaniclastic sediments. Epilastic sediments surrounding a dacite porphyry dome in the Moore deposit contain detrital quartz eyes and debris flows of dacite porphyry. A series of at least seven volcanic centers interfinger, overlap, and are interbedded with locally derived epilastic sediments. Field relations indicate that volcanic dome emplacement, epilastic sediment accumulation, hydrothermal alteration, and gold mineralization were coeval events. Domes were emplaced in a shallow subaqueous environment on the flanks of an emergent volcanic edifice. Hydrothermal cells responsible for gold mineralization are controlled by high-angle faults. These same faults influenced the emplacement of volcanic domes, an essential step in the development of gold ore in the Pueblo Viejo district.

Introduction

Ore deposits in the Pueblo Viejo district represent one of the world’s largest gold–silver resources and consequently are of special interest to exploration geologists. This paper presents the results of detailed deposit-scale and district-scale geologic mapping undertaken by the author during 1996 and 1997. The maps focus attention on a series of previously unrecognized volcanic domes that are spatially and temporally related to hydrothermal alteration and precious metal mineralization. Figure 1 presents a location map for the Pueblo Viejo district and shows the location of surrounding base and precious metal prospects.

A series of distinguished papers address the geologic setting of the Pueblo Viejo district. Kesler et al. (1981) described a restricted submarine basin on the flanks of a volcano, similar to basins near the Momotombo volcano on the margin of present-day Lake Managua, Nicaragua. Sillitoe and Bonham (1984) suggested that a portion of the sedimentary section was actually of pyroclastic origin and proposed a maar–diatreme setting. Under this interpretation, the restricted basin described by Kesler et al. (1981) fills a maar crater and overlies a diatreme. Russell and Kesler (1991) accepted a maar–diatreme as the geologic setting for Pueblo Viejo but suggested that erosion removed the pyroclastic apron. The distinction between pyroclastic, epiclastic, and sedimentary units, long a topic of controversy at Pueblo Viejo, is taken up in detail in the descriptive portions of this paper. Many rock units are reinterpreted based on field relations observed during geologic mapping.
Regional geology

Ore deposits of the Pueblo Viejo district are hosted by the Cretaceous Los Ranchos Formation (Fig. 1), part of one of the oldest and chemically most primitive island arcs in the Caribbean Basin. Donnelly and Rogers (1981) used the term primitive to describe the Los Ranchos Formation and similar volcanic rock suites: (1) that formed at an early stage in the evolution of the island arc; (2) that were not derived by differentiation from any other magma type; and (3) in which large ion lithophile (LIL) elements were not enriched during differentiation.

Previous workers, beginning with Bowin (1966), described volcanic rocks of the Los Ranchos Formation as spilites and keratophyres. Cas and Wright (1995), however, recommended that the classification scheme of Streckeisen (1979) be followed where possible, even for altered volcanic rocks. Consequently, the terms spilite and keratophyre are here abandoned. Volcanic rocks of the Los Ranchos Formation are instead referred to as andesite and dacite, based on phenocryst assemblage and based on the whole rock geochemistry of 26 samples collected by Kesler et al. (1991). Kesler et al. (1991) report a bimodal silica distribution for volcanic rocks of the Los Ranchos Formation, with peaks falling in fields corresponding to basaltic andesite and dacite. Diaz de Villavila et al. (1997) report a similar bimodal chemical signature for Early Cretaceous volcanic rocks in Cuba.

Volcanic rocks in the Pueblo Viejo district were spilitized by their interaction with seawater, were hydrothermally altered during volcanic dome emplacement, and were regionally metamorphosed. Thin section examination reveals strong secondary mineral replacement of both phenocrysts and groundmass. Nonetheless, primary phenocryst phases can often be identified. Use of the term andesite for rocks previously described as spilites is appropriate given the common phenocryst assemblage of plagioclase and clinopyroxene. Some samples contain an altered phenocryst phase that was probably olivine or orthopyroxene (Kesler et al. 1991) and some volcanic dome samples contain phenocrysts of quartz, potassium feldspar, and biotite (Honea, unpublished). The original composition of the Los Ranchos Formation in the Pueblo Viejo district probably varied from basalt, through basaltic andesite, to andesite and dacite.

Mann et al. (1991) assembled pertinent regional studies dealing with the geology and tectonic evolution of the island of Hispaniola. The thrust-bound fragment of ocean floor (peridotite) shown on Fig. 1 has been interpreted as a former subduction zone (Bowin 1975) and as an ophiolite (Draper and Lewis 1989). A paper by Draper et al. (1996) introduced the terms El Altar zone and Ozama shear zone (Fig. 1) for rocks previously assigned to the Early Cretaceous Maimon Formation. Under this interpretation, Aptian to Early Alban obduction of ocean floor was responsible for shearing and metamorphism of volcanic and sedimentary rocks belonging to the Maimon Formation. The Los Ranchos Formation was similarly affected near the Hatillo thrust. Carbonaceous sedimentary rocks of the Los Ranchos Formation exhibit axial plane cleavage and metamorphic recrystallization to phyllite.