Magmatism vs. Mineralization in the Segovia-Remedios and Central Antioquia Au Districts, Colombia

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Introduction

Historic to modern-day gold production from Colombia's Segovia-Remedios and Central Antioquia gold districts (Fig. 1), exceeds 930 metric tonnes, making the region one of the most productive in the entire northern Andes (Sillitoe, 2008). In both districts, the predominant style of mineralization is structurally-controlled quartz+sulfide+\-carbonate veins hosted within or peripheral to major calc-alkaline batholiths; in the case of Segovia-Remedios the Segovia batholith (Jurassic), and in the case of Central Antioquia, the Antioquian batholith (Cretaceous). Due to the lack of modern radiometric dates, the age of gold mineralization in these districts has been assumed to broadly coincide with that of the respective host batholiths (Shaw, 2000; Sillitoe, 2008). New U-Pb and K-Ar age dates and Pb isotopic data presented herein clarifies the temporal relationships between the age of magmatism and gold mineralization in these two mining districts.

Regional Geology

Basement rocks for both the Segovia and Antioquian batholiths include predominantly early Paleozoic metamorphic rocks of the parautochthonous Cajamarca and Valdivia Groups, made up of carbonaceous to graphitic, chloritic and micaceous schist intercalated with carbonaceous meta-psammite, quartzite, marble, quartzo-feldspathic gneiss and amphibolite, all of lower to middle greenschist metamorphic grade (Gonzalez, 2001; Cediel et al., 2003). The principle tectonic features are the Palestina and Romeral fault and suture systems. The tectonic development of these two features played a first order role in the localization, structural evolution, post-cooling deformation and modern-day expression of the batholiths and their contained vein-related gold mineralization.

Magmatism vs. Mineralization at Segovia-Remedios

Dozens of structurally-controlled Au-bearing quartz-sulfide veins are hosted within the N-S trending Segovia batholith. Occurrences tend to cluster in districts, the historically most important of which is Segovia-Remedios, where a significant portion of the production (>100 metric T Au) has come from three veins: El Silencio, Providencia and Sandra K. These veins exhibit coarse-grained sericite-stable alteration halos. An intimate spatial relationship is observed between the veins and fine-grained dolerite and granodiorite porphyry dykes. Samples of the Segovia batholith diorite and a granodiorite porphyry dyke collected in the Providencia mine returned U-Pb (zircon) ages of 158.7±2.0 Ma and 85.9±1.2 Ma, respectively. The dolerite dykes produced no zircon separate. Hydrothermal sericite from a batholith diorite enclave encapsulated within the Providencia vein returned 88±2 Ma whilst K-Ar (whole rock) analyses of the sericite-altered Providencia granodiorite porphyry dyke returned 88±3 Ma and a similarly altered dolerite dyke at Sandra K returned 84±3 Ma (Fig. 2).

Magmatism vs. Mineralization in Central Antioquia

The Antioquian batholith and it's satellite intrusions represent the largest expression of Cretaceous-aged plutonism in the northern Andes. As with the Segovia batholith, dozens of structurally-controlled Au-bearing quartz-sulfide veins are hosted within and peripheral to the Antioquian batholith. Twelve new U-Pb (zircon) ages and petrochemical considerations for the Antioquia Batholith reveal at least three well-defined magmatic pulses: 89-78Ma, 78-70Ma and 61-58Ma (Fig. 2). One satellite stock (La Culebra), which out crops along a NE-trending corridor less than 3 km to the SW of Segovia-Remedios returned a U-Pb (zircon) date of 87.5±1.6Ma. With respect to Au mineralization, only one deposit hosted within the Antioquian batholith, Gramalote (resource approaching 100 metric T Au) has been studied in detail (Leal-Mejía and Melgarejo, 2008). U-Pb (zircon) dating at Gramalote reveals mineralization is hosted within the 61-58Ma phase of the batholith. Molybdenite from mineralized veins returned 58.5±0.3 Ma (Re-Os) whilst alteration sericite from a vein selvage returned 58±2.3 Ma (K-Ar) (Fig. 2). No attempts have been made elsewhere to date vein-type mineralization within the batholith, as weathering and oxidation render potentially datable materials unsuitable.

Pb Isotopes

Lead isotopic analyses were undertaken on pyrite from numerous gold districts, including El Bagre (El Carmen vein) and Segovia-Remedios (El Silencio vein) in the Segovia batholith trend, and Santa Rosa de Osos, La Floresta and Gramalote within the Central Antioquia district (Fig. 1). Results reveal that the Segovia-Remedios samples and Central Antioquia samples plot within the same narrow $^{206}Pb/^{204}Pb$ range (Fig. 3), suggesting a similar Pb isotopic source for mineralization in both Segovia-Remedios and Central Antioquia. The El Bagre samples, and samples from other more distant Au districts plot in clearly distinct arrays (Leal-Mejía et al., 2009).

Conclusions

The Segovia-Remedios and Central Antioquia gold districts represent at least two Au metallogenic pulses: Segovia-Remedios (ca. 88-86Ma) and Gramalote (ca. 60-58Ma). Based upon our results, we discard any direct link between the cooling history of the middle-late Jurassic Segovia batholith and the Au deposits of the Segovia-Remedios district, where U-Pb crystallization ages, K-Ar alteration ages, Pb isotopic data and the spatial-structural relationships between Au mineralized veins, granodiorite porphyry dykes and the nearby La Culebra stock all support a temporal relationship between mineralization and emplacement of the 89-78Ma phase of the Antioquian batholith. At Gramalote, a direct temporal and spatial relationship between the 61-58Ma phase of the Antioquian batholith, the presence of molybdenite, and alteration associated with Au mineralized veins is observed.

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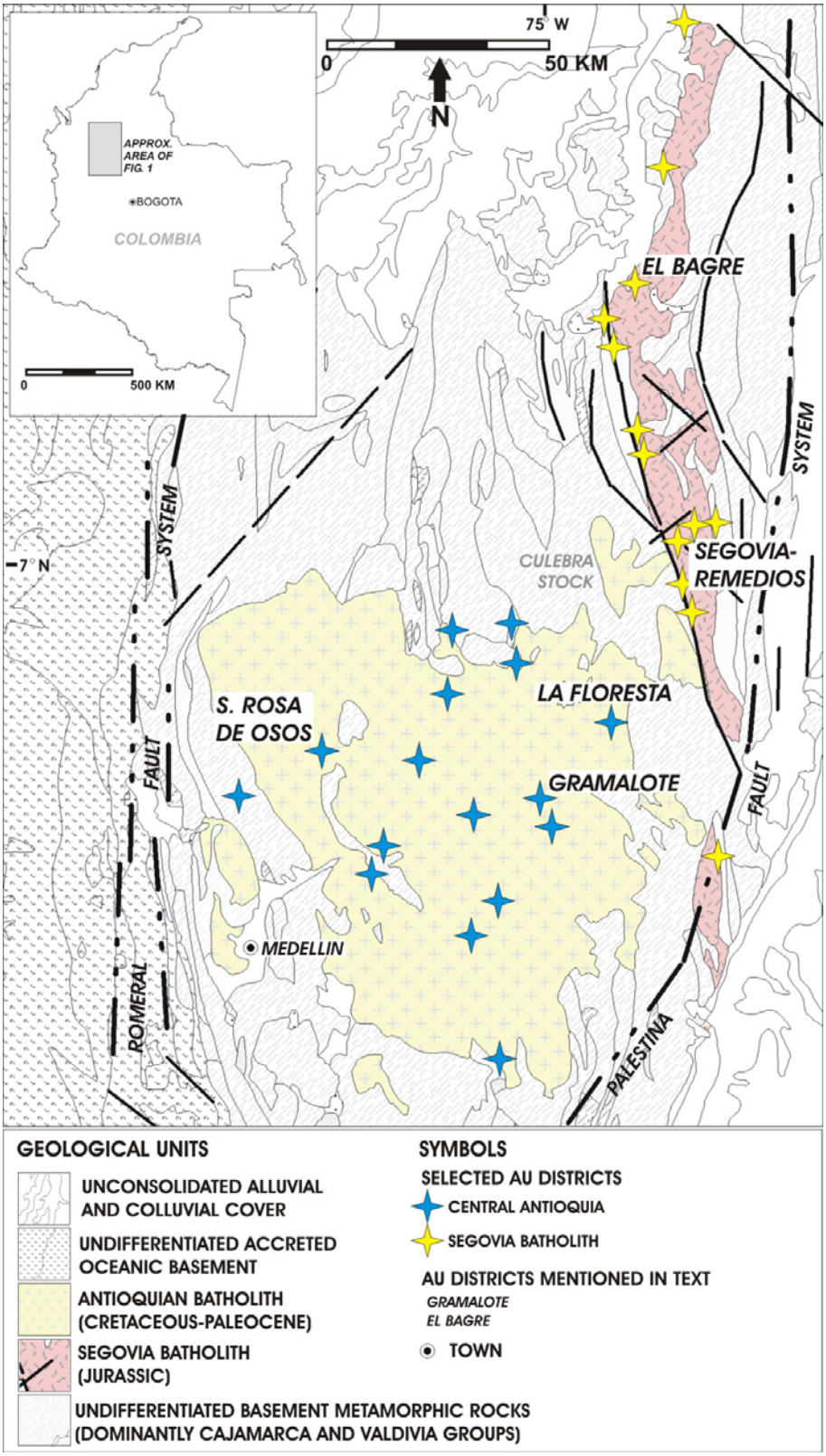

Fig. 1. Location and simplified geology of the Segovia-Remedios and Central Antioquia gold districts, Colombia.

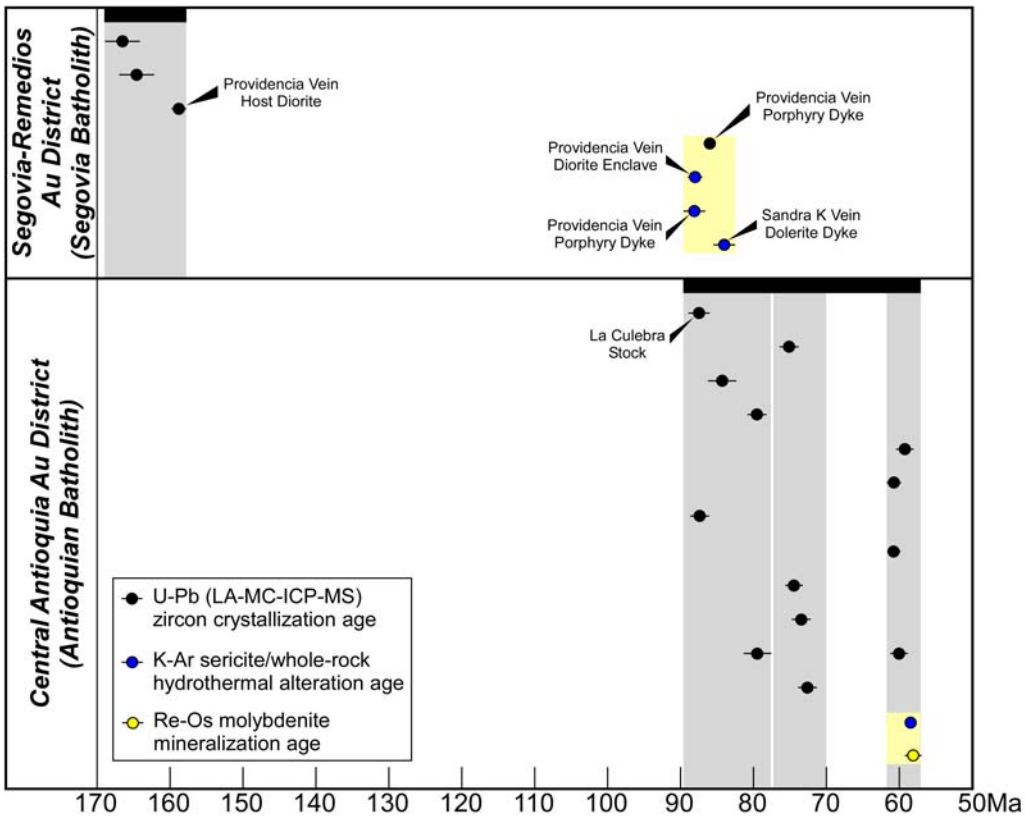

Fig 2. U-Pb (zircon), K-Ar, and Re-Os ages for the Segovia and Antioquian batholiths and some spatially associated Au districts.

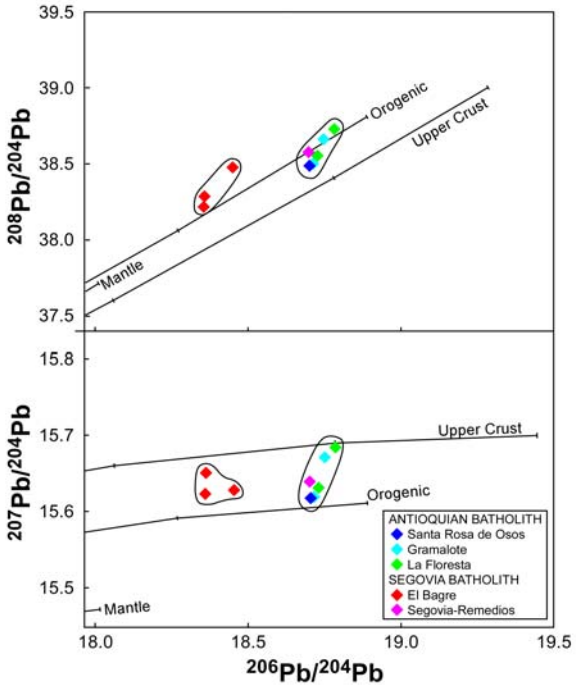

Fig. 3. Uranogenic and thorogenic diagrams showing Pb isotopic composition of pyrite from some Au occurrences hosted within the Segovia and Antioquian batholiths, Colombia.