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EVAPORITIC ORIGIN OF THE PARENT BRINES OF COLOMBIAN EMERALDS: FLUID INCLUSION AND SULPHUR ISOTOPIC EVIDENCES

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The Colombian emerald deposits present a very special character mainly due to their peculiar geological setting and origin. Actually, the two emerald belts of the Eastern Cordillera are located within Upper Cretaceous black shales. The emerald mineralization formed due to a strong fluid/rock interactions including multi-scale chemical components transfer. Particularly evident is the Cr-V-REE mobilization from black shales to vein-filling precipitates and their incorporation within the green muscovite, emerald or REE-dolomite crystal lattices (Giuliani et al., 1990a). Other evidences concern the nature of hydrothermal fluids related to wall-rock interaction haloes and vein precipitations.

Fluid inclusions studies by destructive and non-destructive methods reveal the constant presence of either three-phase (halite, brine and gas phase or multiphase inclusions with CO_2(L+V), N_2 and several daughter minerals. Scanning electron microscopy (SEM) permitted to identify in addition to halite, also sylvite and other chloride components like chloride of Ca, Fe, Mn and Cr (Giuliani et al., 1990b). The presence of complex NaCl – $CaCl_2$ – X (unknown) brines is confirmed by microthermometric and Raman data obtained on emerald crystals from the Coscuez, Vega, Diamante and Chivor deposits (during freezing experiments, eutectic temperatures ranged from –60 to –50°C, final melting temperatures of ice from –33 to –17°C and metastable hydrate with unknown Raman spectra nucleated).

Estimation of the fluid trapping temperatures in inclusions appears difficult mainly due to the mechanical behaviour of emerald crystal during heating experiments (common inclusions leakage and decrepitation) and the complexity of their chemical composition. Isochoric extrapolation in a simplified NaCl-H_2O system (total salinity 37-40 wt.% eq. NaCl) constrained by the $^{40}Ar/^{39}Ar$ formation age determination (Cheilletz et al., 1991) and the Eastern Colombian Cordillera subsiding model (Hebrard, 1985), leads to a pressure-temperature estimate of 1.12-1.06 kb and 290-360°C for Coscuez emerald deposition.

The origin of the hydrothermal fluids invoked for the emerald genesis can be approached through the sulphur isotopic study of the generation of pyrite which coprecipitated with emerald. Sulphur isotopic composition of pyrites from four deposits (Chivor, Mina, Coscuez and Muzo) have been determined. The $\delta^{34}S$ are comprised between +15 and +21.2‰ whereas sedimentary nodular pyrite from the enclosing black shale yield a $\delta^{34}S$ of –2.43‰. From these data, several conclusions can be addressed: (1) the narrow range in $\delta^{34}S$ variations from the different deposits suggests a uniform and probably unique source for the sulphide sulphur; (2) the participation of sedimentary sulphur extracted from the enclosing black shale can be excluded; (3) the participation of magmatic sulphur is precluded, even if considering a $\delta^{34}H_2S$ enrichment through decreasing fO_2.

The composition of the fluids trapped within pyrite was evaluated by SEM and energy dispersive analysis of individual inclusion decrepitates. It dominantly consists of Na-Ca brines with significant amounts of KCl. Such composition is similar to the fluids associated with emerald crystals (complex H_2O-NaCl-$CaCl_2$-KCl-CO_2-N_2 brines, Giuliani et al., 1990b).

Conclusions. The Lower Cretaceous $\delta^{34}S$ marine sulphate ranges between +15 and +18‰ (Claypool et al., 1980). The Berriasian and Valanginian series underlying the emerald-bearing black shales contain evaporitic levels. The brine-bearing hydrothermal fluids trapped in emerald and associated minerals (pyrite, dolomite, quartz, fluorite) are similar to the fluids associated to Pb-Zn deposits related to salt diapirs (Guilhaumou et al., 1981) or metamorphosed evaporites (Mc Kibben et al., 1988). Therefore, these Lower

Cretaceous evaporitic sulphate levels appear as the most likely source of the hydrothermal fluids sulphur components as well as their NaCl content. The evaporitic origin of sulphur and brine components of the hydrothermal fluids genetically linked with the Colombian emerald-bearing veins, suggested earlier by Kozlowski et al. (1988), appears as a prevailing and remarkable feature of these emerald deposits.

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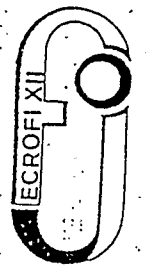

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ABSTRACTS

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