STRUCTURAL SETTING AND AGE OF THE COLOMBIAN EMERALD DEPOSITS: IMPLICATIONS FOR THE TECTONIC EVOLUTION OF THE CORDILLERA ORIENTAL

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The Cordillera Oriental of Colombia houses a unique type of emerald deposit entirely related to sedimentary rocks and tectonic-hydrothermal processes. But, quite surprisingly, there are two groups of such deposits that differ greatly by their structural setting and age. The western deposits (WD : Muzo and Coscuez deposits...) are located north of Bogotá, in the western part of the mountain belt, at some distance from the middle Magdalena basin. The eastern deposits (ED : Chivor deposit...) are located to the northeast of Bogotá, near the eastern border of the cordillera, not far from the Llanos basin. The deposits crop out in two anticlinoria resulting from the inversion of a Cretaceous subsident basin and its thrusting over both middle Magdalena and Llanos basins. The emerald deposits provide important clues to the tectonic evolution of the Eastern Cordillera.

Main common characteristics of the WD and ED are : (i) close linkage with evaporites (halite and gypsum/anhydrite) and black shales; (ii) Lower Cretaceous hosting rocks; (iii) a same mesothermal-sedimentary genetic model, involving generation of hot brines (280-300 °C) through evaporite dissolution by basinal waters, thermochemical sufate reduction, Na-Ca metasomatism of black shales (albitization and carbonatization), coeval leaching of beryllium and pyrite-calcite-dolomite-bitumen-emerald precipitation; (iv) intense hydro-thermal-tectonic breccias development. Hydrothermal breccias underline the tectonic contacts that acted as channels for the mineralizing fluids.

The WD are hectometer- to kilometer-sized, highly complex associations of thrusts, reverse faults, drag folds, ramp folds, duplexes, strike-slip and tear faults and flowers structures of varied orientations, all attesting a very heterogeneous compressive deformation of the mineralized Valanginian-Hauterivian series. At a larger scale, the deposits are disharmonic structures residing in the core of plurikilometer-sized, upright anticlines, regularly trending parallel to the belt, i. e. N20°E, and associated with a strong axial plane cleavage. These folds are linked to west-vergent reverse faults and, at this regional scale, the cordillera is an ordinary fold-and-thrust belt. Structural analysis shows that the small

deposits and the large anticlines are coeval. The overall structure implies a concealed décollement that probably is the evaporite level from which originated the mineralizing fluids. Logically, such a décollement must be also a major floor thrust along which the belt was thrusted, probably westward. Mineralization, and consequently the regional deformation, is dated by K/Ar and Ar/Ar methods at 38-32 Ma, i.e. Upper Eocene to lowermost Oligocene. Other data are consistent with this conclusion; for example, folding and thrusting is known to have occurred as early as Middle Eocene in the middle Magdalena area. Thus, in the WD area, the cordillera became a fold-and-thrust belt long before the Neogene Andean uplift.

The ED are scattered along a Berriasian-Valanginian stratigraphic level. This level contained evaporites, now largely dissolved and replaced by a huge hydrothermal breccia. Mineralization occured within or very close to the breccia level (here, contrary to the WD, source of and sink for the mineralizing fluids are coincident). All tectonic structures coeval with the mineralizing event are strictly linked to the breccia level and are extensional: normal faults and tension gashes associated with the collapse of the breccia level roof. At this time, the breccia level acted as a detachment, possibly gravity-driven owing to a favorable dip of tilted blocks. But it has not been possible to characterize the regional tectonic regime as extensional, though there is no clear evidence of any compressive structure at this time. Mineralization and related extensional structures are well dated by K/Ar and Ar/Ar methods at 65±3 Ma, i.e. the Cretaceous-Tertiary boundary. This time is also known as one of important reorganization of the basin extending over the easternmost cordillera and nearby Llanos basin. Later on, the mineralized stratiform level, together with the whole Cretaceous-Tertiary series, was passively folded and thrusted eastward by the Andean tectonics from Middle Miocene to Actual (Branquet et al., this volume). Here, contrary to the western zone, there is absolutly no link between this fold-and-thrust regional structure and the mineralizing event.

In summary, we propose that, in the Eastern Cordillera of Colombia, the fold-and-thrust belt formation is diachronous: (i) in the east, structuration began at the Cretaceous-Tertiary boundary with the tectonic event linked to the emerald mineralization, whereas the east-vergent fold-and-thrust belt formation is supposed to be not older than Middle Miocene; (ii) in the west, the west-vergent fold-and-thrust belt developed earlier, in Upper Eocene to lowermost Oligocene time. So, the east side story was very different from the west side story.

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Reference:

Branquet, Y., Laumonier, B., Cheilletz, A., Giuliani, G. 1999. Emeralds in the Eastern Cordillera of Colombia: two tectonic settings for one mineralization. *Geology*, in press.