DEFORMATION HISTORY OF THE BLUESCHIST-FACIES SEQUENCES FROM THE VILLA DE CURA UNIT (NORTHERN VENEZUELA)

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ABSTRACT

The structural history of the Villa de Cura blueschists-facies units includes four main deformational phases, from D1 to D4. The first D1 phase is mainly represented by a relict S1 schistosity developed under HP/LT conditions. The relic S1 schistosity is deformed by isoclinal to subisoclinal F2 folds showing similar geometry. The F2 folds are characterized by a continuous S2 crenulation cleavage developed under greenschist-facies metamorphism. The parallelism between the A2 axes and the related L2 mineral lineations suggests an interpretation of the F2 folds as sheath folds developed during non-coaxial deformation. The kinematic indicators suggest a top-to-W sense of shear for the D2 phase. The D3 phase is distinguished by asymmetric, parallel F3 folds with high-angle to sub-vertical axial planes. The D4 phase consists of F4 open, gentle folds with high-angle to sub-vertical axial planes. The collected data suggest a complex deformation history, characterized by coupling of strike-slip tectonics and shortening during the retrograde evolution of the blueschist-facies sequences.

INTRODUCTION

However, the reconstruction of the geodynamic evolution of the southern margin of the Caribbean plate displays several open problems, owing to the lack of detailed investigations on the structural and metamorphic features of the displaced terranes. At this regard, the high-pressure low-temperature (HP-LT) units may provide important geological constraints for the geodynamic reconstruction, helping to determine the dipping direction of the Cretaceous subduction(s) as well as the exhumation mechanism of the HP-LT rocks.

The geological setting and the metamorphic evolution of the main HP-LT units of Northern Venezuela (i.e., the Margarita Complex, Franja Costiera-Cordillera de la Costa, and Villa de Cura unit) have been recently outlined in detail (Avé Lallemant, 1997; Giunta et al., 1997; Sisson et al., 1997; Smith et al., 1999, Maresch et al., 2000), whereas the deformation histories of these units are still poorly constrained.

In this paper we present the preliminary results of detailed structural analyses of the HP-LT Villa de Cura unit and we discuss the related tectonic implications.

GEOLOGICAL SETTING

The Serrania del Interior terrane is located in Northern Venezuela, that represents the southern margin of the Caribbean plate. This terrane includes the Villa de Cura unit, which mainly consists of multiple sub-units of metamorphosed and deformed Cretaceous volcano-sedimentary sequences. These sequences are commonly interpreted as generated in a supra-subduction zone setting. The structural history of the Villa de Cura blueschists-facies units includes four main deformational phases, from D1 to D4. The first D1 phase is mainly represented by a relict S1 schistosity developed under HP/LT conditions. The relic S1 schistosity is deformed by isoclinal to subisoclinal F2 folds showing similar geometry. The F2 folds are characterized by a continuous S2 crenulation cleavage developed under greenschist-facies metamorphism. The parallelism between the A2 axes and the related L2 mineral lineations suggests an interpretation of the F2 folds as sheath folds developed during non-coaxial deformation. The kinematic indicators suggest a top-to-W sense of shear for the D2 phase. The D3 phase is distinguished by asymmetric, parallel F3 folds with high-angle to sub-vertical axial planes. The D4 phase consists of F4 open, gentle folds with high-angle to sub-vertical axial planes. The collected data suggest a complex deformation history, characterized by coupling of strike-slip tectonics and shortening during the retrograde evolution of the blueschist-facies sequences.
Fig. 1 - A) geodynamic framework of the Caribbean Plate; B) tectonic sketch map of the Northern Venezuela; C) geological section across the Northern Venezuela (1: LH=Las hermanas unit; 2: VC=Villa de Cura unit; 3: LdH=Loma de Hierro; 4: Ct=Cacagua-El Tinaco unit; 5: Fc=Franja Costiera unit; 6: CC=Cordillera de la Costa unit; 7: Piemontine nappe; 8: Folded sedimentary cover of the Guyana shield; 9: Sedimentary cover of the Guyana shield)

DEFORMATION HISTORY

The structural analysis has been performed on the Villa de Cura sub-units (i.e. sub-belts 2, 3 and 4 of Smith et al., 1999) affected by blueschist metamorphism. Four deformation phases, from D1 to D4, have been identified in the field as well as in thin section.

The first D1 phase, is represented by a S1 foliation, which can be observed as a relict only in the hinge zone of F2 folds. This foliation can be classified as a schistosity developed under blueschist-facies conditions. The syn-D1 metamorphic paragenesis generally includes by albite + quartz + chlorite, ± phengite ± titanite; nonetheless, the occurrence in the southernmost sub-unit of amphibole zoning from barroisitic cores to glauco- phanitic rims seems to indicate the occurrence of an anomalously high geothermal gradient coherent with an atypical counterclockwise P-T path (Smith et al., 1999).

d) the Las Hermanas unit, that consists of a sequence of basaltic-andesites interlayered with volcanic breccias and tuffs. This sequence is commonly referred to as part of a “mid”Cretaceous island arc generated in an intra-oceanic supra-subduction setting (Navarro, 1983; Ostos, 1990; Beccaluva et al., 1996).
observed blueschist-facies assemblages allow to constrain the climax metamorphic conditions of the Villa de Cura unit in the range of 600 MPa < P < 750 MPa and 375 < T < 450°C. On the S1 foliation, mineral lineations are represented by elongated epidotes, Na-amphiboles and lawsonite showing a N/S, down-dip trend (Fig. 2). Moreover, the quartz veins transposed by S2 foliation can be interpreted as syn-tectonic extensional veins which developed during D1 phase.

The second D2 phase, is characterized by isoclinal to subisoclinal F2 folds with similar geometry and subrounded to subangular hinges (Fig. 3). The folded surfaces are quartz veins or layers with different lithological composition and/or grain size. The F2 folds, generally rootless, have thickened hinges and boudinaged limbs. The limbs generally show well-developed pinch-and-swell structures. Mullion structures are also present. In the related stereonet (Fig. 2), the distribution of A2 axes is scattered, even if a cluster corresponding to a SE-NW trend can be easily identified. The F2 folds are characterized by a well-developed and continuous S2 axial plane foliation, that is a continuous crenulation cleavage developed under greenschist-facies conditions. At the mesoscale, this foliation occurs as the main structural surface, and it is everywhere parallel to the boundaries among the blueschist-facies sub-units. The syn-D2 metamorphic assemblage, marked by albite + chlorite + quartz + actinolite ± pumpellyite ± white mica ± calcite ± epidote, suggests T < 300°C and P < 550-600 MPa. A composite foliation, resulting from overprinting of the S1 foliation by the S2 one, is well recognizable in the limbs of the F2 folds. The L2 mineral lineations consists of elongated minerals such as chlorite and white mica aligned along the S2 foliation; the related stereonet (Fig. 2) reveals that the L2 trend ranges from ESE/WSW to ENE/WSW. On the whole, the F2 axes trend is roughly parallel with the related L2 mineral lineations (Fig. 2). Furthermore, the boudins long axes are usually coaxial with the F2 axes. This feature seems to suggest an interpretation of the F2 folds as sheath folds developed during a non-coaxial deformation history. The kinematic indicators, mainly s-type porphyroclasts of magmatic pyroxenes and s-type porphyroblasts of epidote, suggest a top-to-W sense of shear (Fig. 4).

The D3 phase is characterized by asymmetric F3 folds, with approximately parallel geometry and rounded hinges. The S1 and S2 surfaces are folded by F3 folds (Fig. 2). The F3 folds, ranging from subisoclinal to open folds, are cylindrical, with east-west trend of the A3 axes (Fig. 2). The axi-
al plane foliation consists of a spaced S3 crenulation cleavage, which occurs as sub-horizontal surface. During the D3 phase recrystallisation of quartz + albite + stilpnomelane ± white mica occurred. The asymmetry of the F3 folds consistently indicates a southward vergence.

The D4 phase is represented by F4 open, gentle folds with high-angle to sub-vertical axial planes. The F4 folds show a scattered trend, but a cluster corresponding to a NNE/SSW trend can be observed also (Fig. 2). A well-spaced disjunctive cleavage represents the axial-plane foliation associated to the F4 folds.

The SE/NW trending faults and the associated sub-vertical quartz veins are the youngest tectonic structures.

**DISCUSSION AND CONCLUSIONS**

The outlined structural evolution of the Villa de Cura HP-LT sub-units implies a complex deformation history, here described in detail for the first time. This history consists of four phases mainly developed during retrograde metamorphism, from blueschist-facies to very low-grade conditions. The deformations features allow some considerations about the geological history of the blueschist-facies sequences.

Firstly, the parallelism between the S2 foliation and the boundaries of the Villa de Cura sub-units suggest that all these sub-units were coupled during the D2 phase, that largely obliterated the previous deformations achieved during the D1 phase.

In addition, the D1 phase is clearly related to subduction of the Villa de Cura sub-units which show blueschist-facies metamorphism, as suggested by Navarro (1983), Ostos (1990), Beccaluva et al. (1996) and Smith et al. (1999). The only D1 phase relicts, mainly represented by the S1 foliation, as well as rare quartz veins, do not allow determination of the sense of shear during the D1 phase. Thus, the dip of the subducting slab where the blueschist-facies sub-units were involved remains undetermined. Moreover, the D2 phase is characterized by sheath folds associated to L2 mineral lineations showing a rough east-west trend. This trend is parallel to the present-day strike-slip faults that are in turn parallel to the boundaries of the main Northern Venezuela terranes, as discussed also by Smith et al. (1999). This suggests that the exhumation of the blueschist sub-units during the D2 phase was probably largely controlled by strike-slip tectonics. On the contrary, the structural evidence for the D3 phases reveals a clear top to S sense of shear, that suggests a southward displacement of blueschist-facies sub-units during their final stage of the retrograde metamorphic history. The collected data suggest a transpressive deformation history, where strike-slip tectonics was coupled with ductile shortening during the whole retrograde evolution of the Villa de Cura blueschist-facies sub-units.

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