# The authigenic quartz crystals from Villaseca (Cuenca, Spain)

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## INTRODUCTION

Recently, quartz samples ranging from single crystals to multicentimeter aggregates and druses were collected near the village of Villaseca, in the northern sector of Cuenca province (Fig. 1A). The quartz ranged from pale brown color to dark brown, almost black, and attracted the attention of mineral collectors.

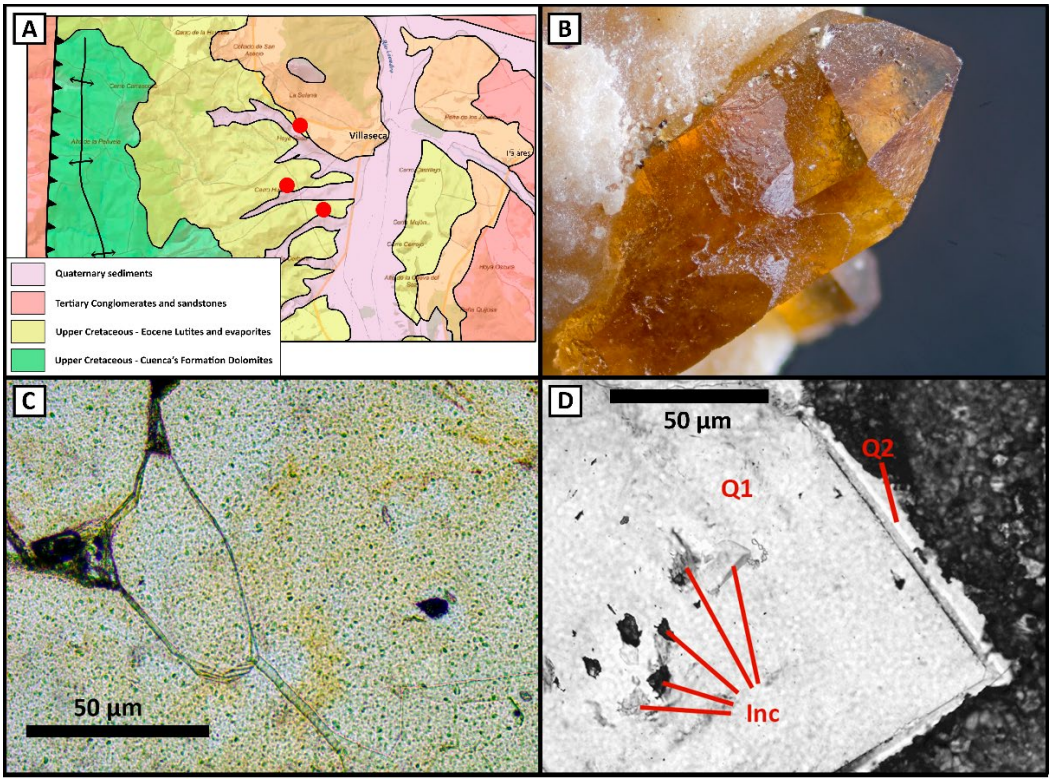


***Fig 1**. A) Simplified geological map of the vicinity of Villaseca. Sampling locations are marked with red and white dots. Adapted from Instituto Geológico y Minero de España (1983). B) Picture of a 1 cm quartz crystal within the lutite matrix. Microscope image of inclusions trapped within quartz crystals. C) Inclusions are pervasive, ranging in size from >1 to 25 microns, and the mainly contain fluids, clay or evaporites. D) Microscope image of the contact between quartz crystals and the matrix. Q1: Core crystal. Q2: Overgrowth. Inc: Solid inclusions within the quartz.*

## GEOLOGICAL BACKGROUND

Villaseca is situated on the Villalba de la Sierra Formation (Melendez, 1971), composed mainly by clays, marls and evaporates (gypsum). It spans from the Senonian to the Middle Eocene periods and registers a change in the environmental conditions of the Iberian Basin: from hypersaline marine sabkhas to more continental and siliciclastic facies. It lies above the Brechas Dolomíticas de Cuenca Formation, a pure evaporitic sabkha unit and is capped by

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Tertiary continental deposits. The presence of authigenic quartz crystals within lutite beds in lithologies equivalent to this formation has been documented by Gutiérrez and Robles (1976) in the Priego area, including some with a distinct red hue. This occurrence is also recorded in various sheets of the MAGNA series by the Instituto Geológico y Minero de España (IGME) (e.g., Sheet No. 563 (Ledanca), Sheet No. 586 (Priego)). Recent work by Herrero et al. (2020) has identified similar authigenic quartz occurrences in multiple sites across the Iberian Range (Spain).

## METHODOLOGY AND RESULTS

Samples were collected from several outcrops of the VillaIba de la Sierra Formation surrounding Villaseca and were analyzed by thin-section petrography, Raman spectroscopy, pyrolysis analysis, and biomarker extraction for comprehensive characterization. Quartz crystals are embedded in a matrix primarily of shale with minor gypsum and native sulfur. When fractured, the material releases a strong hydrocarbon odor. The quartz crystals exhibit euhedral to sub-euhedral forms, with prevalent prismatic and bipyramidal morphologies, ranging in color from pale brown to brownish black (Fig. 1B). Under thin-section analysis, quartz crystals contain numerous inclusions (Fig. 1C), including clay and gypsum, like the matrix, along with occasional fluid inclusions containing organic matter. Quartz appears as individual, well-formed crystals or in clusters. Individual crystals show sharply defined terminations and complete extinction, with some displaying evidence of secondary overgrowth that keeps incorporating portions of the surrounding matrix along their edges (Fig. 1D). In contrast, quartz clusters comprise smaller crystals with less distinct morphology than isolated crystals. Total carbon found was up to 8% in the matrix and below 0.1% within the quartz. Organic extractable material analysis of quartz crystals showed no presence of hydrocarbons or molecular biomarkers, even in the darker crystals. Matrix analysis showed only traces of hydrocarbons, suggesting that organic carbon presence is limited to occluded gas and non-extractable carbon.

## INTERPRETATION

Bipyramidal quartz crystals with clay inclusions are relatively common and are colloquially referred to as "Jacintos de Compostela" in Spain, a categorization that applies to the quartz crystals studied here. Due to its yellowish-brown color of the lighter crystals, the quartz has been labeled in collections as “citrine”. However, this varietal denomination is not correct; the lighter color is not due to color centers and crystals do not show color change after heating at 500ºC. While authigenic silica, such as chert or opal, is common in carbonate sequences globally (Friedman, 1980), the monocrystalline quartz observed in this study seems to have grown within a matrix already packed with clay and evaporites. This is likely due to the dissolution of pre-existing evaporites that precipitated in a sabkha setting. Such evaporitic layers become increasingly metastable with the onset of marine regression during the Late Cretaceous-Paleogene, as continental influences and freshwater inputs increase. The disappearance of these evaporites creates voids conducive to quartz growth in a silica-supersaturated milieu. Organic matter may contribute to silica supersaturation in solution without requiring elevated temperatures or pH. Organic ligands, such as citrates or oxalates, can enhance the transport capacity of silicic acid in aqueous solutions (Bennett et al., 1988), thus allowing silica sourcing beyond the immediate sabkha environment.

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