ORIGINAL ARTICLE

Variability of Vega Alta Formation in Placetas sector, Villa Clara province, Cuba

Variabilidad facial de la Formación Vega Alta en el sector Placetas, Villa Clara, Cuba central Facial

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Abstract

The study aims to identify facies within the lithostratigraphic unit, update bioevents and biostratigraphic ranges of the drilled sequences, and interpret the paleoenvironment during basin infilling. Data from the deep wells *Long Year* (1, 1A, 2) and *Sullivan* 6 were analyzed. Twelve lithofacies were identified, revealing two major heterogeneous sedimentary groups influenced by tectonics: (1) an olistostromic group with abundant limestone olistoliths of varying sizes and Jurassic–Cretaceous ages, and (2) a less common siliceous–carbonate group within a sandy clay matrix. The Vega Alta Formation is dated to the Paleocene–early Eocene, with redeposited Jurassic and Cretaceous microfossils. Integration of lithological and paleontological data indicates a Paleogene synorogenic basin environment. According to the Wilson Model, sequences from the *Long Year* 1, 1A, and 2 wells correspond to facies belt 4 in a slope zone, while *Sullivan* well 6 corresponds to facies belt 3 at the slope base.

Keywords: facies variability, lithofacies, bioevents, paleoenvironments

Resumen

La investigación se centró en la variabilidad facial de la Formación Vega Alta en el sector Placetas, provincia Villa Clara, Cuba central. Tuvo el objetivo de identificar las facies de la unidad litoestratigráfica, actualizar los bioeventos y rangos bioestratigráficos de las secuencias cortadas, e interpretar el paleoambiente durante el rellenamiento de la cuenca, mediante el estudio de los pozos profundos *Long Year* 1, 1A, 2 y *Sullivan* 6. Como resultado se determinaron doce litofacies, que responden a la variabilidad facial de la unidad, que muestra dos grandes grupos heterogéneos de sedimentos afectados por la tectónica, uno de naturaleza olistostrómica, con abundantes olistolitos de calizas de diferentes tamaños y edades cretácicas-jurásicas; y el segundo, menos representado, de naturaleza silícea-carbonatada en una matriz arcillosa arenosa. La edad de la Formación Vega Alta se establece como Paleoceno-Eoceno temprano, con redeposición (reelaboración tafonómica) de microfósiles jurásicos y cretácicos. Con la integración de los datos lito-paleontológicos se determinó el paleoambiente existente durante el rellenamiento de la cuenca sinorogénica paleogénica; las secuencias de los pozos Long Years 1, 1A y 2 corresponden en el Modelo de Wilson, con el cinturón facial 4 en una zona de talud, y el pozo *Sullivan* 6 con el cinturón facial 3, al pie del talud.

Palabras clave: variabilidad facial, litofacies, bioeventos, paleoambientes

1. INTRODUCTION

The Vega Alta Formation is the regional seal of the Cuban Northern Petroleum Belt (CNPB); it is constituted by sequences of impermeable rocks, indispensable for the existence of the trap, which prevent the fluid from escaping, allowing its preservation. When these rocks are located above the mature source rock, they largely control the regional distribution of hydrocarbons (Snieguiriova *et al*., 1975; Pérez-Martinez *et al*., 2007; Morales-Echeverría *et al*., 2013).

The Vega Alta Formation constitutes a synorogenic sequence deposited in an ancient foreland basin, of Paleocene and Eocene age, originated by complex tectono-sedimentary events of that evolutionary stage, and lies chaotically over the sequences of the Veloz Group of the Placetas Tectonostratigraphic Unit (PTU Placetas), the Amaro Formation and the so-called Canasí Crests. It possesses chaotic rock sequences of turbiditic origin, and of siliceous clayey carbonate nature, characterized by intercalations of siltstone, shale, clay, marl and silicite. Such lithofacies were reported in most of the CNPB wells, the study of these lithofacies towards the central part of Cuba being insufficient (Valladares *et al*., 2006; García-Delgado *et al*., 2011; Morales-Echeverría *et al*., 2013).

The objective of this research was to identify the facies of the lithostratigraphic unit, update the bioevents and biostratigraphic ranges of the drilled sequences, and interpret the paleoenvironment during basin infilling, through the study of deep wells in the Placetas sector, Villa Clara province.

This investigative work contributes to project 6511 "Integral stratigraphic reevaluation of blocks 13, 21a and 21 (Villa Clara-Sancti Spíritus-Ciego de Ávila) for hydrocarbon exploration" (2022-2024) and to the project "Complex Clastic Unit of the Cretaceous--Paleogene Boundary in Cuba and its Relationship with Geological Evolution" (2024-2026) of CEINPET, within the sectoral programs directed by the Institute of Geology and Paleontology / Geological Survey of Cuba (IGP/SGC).

1.1 Geological context

The Placetas municipality is located in the central region of Cuba, southwest of Villa Clara province. With a territorial extension of 600.59 km², it ranks sixth among the thirteen municipalities that make up the province. It borders to the north with Camajuaní, to the northwest with Remedios, to the south with Fomento and to the southeast with Cabaiguán, both belonging to the province of Sancti Spíritus; to the southwest with Manicaragua and to the west with Santa Clara, the provincial capital.

The PTU Placetas comprises a sequence of rocks from the Late Jurassic-Cretaceous, deposited on the paleoslope of the Florida-Bahamas platform and the Protocaribbean basin with more abyssal facies, and south of the Camajuaní UTE (Figure 1).

It outcrops in several localities of the Northern Las Villas Mountain Range and in the Sierra de Camaján in Camagüey. It is constituted by a thick carbonate-siliceous and partially terrigenous sequence, representative of the continental glacis, spanning the interval from Tithonian to Maastrichtian (Blanco, 1999). This zone includes the following units: Constancia Fm. (Truitt and Pardo, 1953), Veloz Gr. (Hatten *et al*., 1958), Santa Teresa Fm. (Wassall, 1952), Carmita Fm. (Truitt, 1953) and Amaro Fm. (Wassall, 1953).

The lithological sequences that make up the Placetas zone are strongly dislocated by folding and faulting. The latter are perpendicular to the general strike of outcrop and have led to the formation of a block/scale system that appear as tectonic wedges. This fact results in the absence of a complete section and that the structure of the zone has been reconstructed from isolated sections, represented in the different tectonic nappes (Orosa *et al*., 2021).

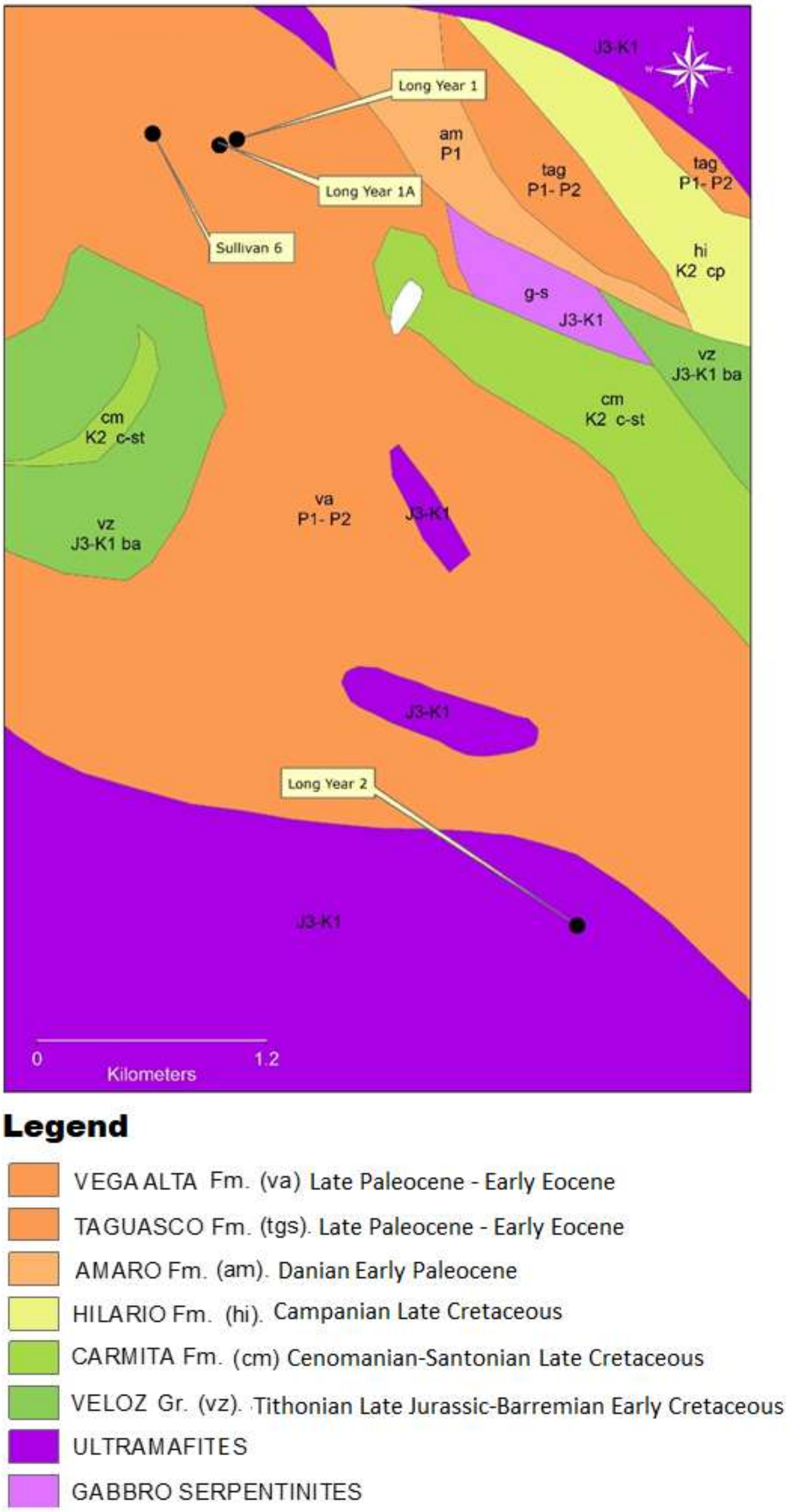

Figura 1. Location of the deep wells analyzed in the Placetas Sector, Villa Clara. Modified from Geological Map of Cuba 1:100,000 (2010).

2. MATERIALS AND METHODS

The primary information available in the records of wells Long Year 1, Long Year 1A, Long Year 2 and Sullivan 6, from the technical archive of CEINPET and the National Office of Mineral Resources (ONRM), was reviewed in order to carry out the stratigraphic re-elaboration and the preparation of the geological columns using the Strater software.

The geophysical well logs were digitized with the NeuraLog Version 2008.05 computer program from FlexLM. Subsequently, the petrophysical reinterpretation of the well sequences was undertaken, with the support of Interactive Petrophysics (IP) version 3.4 and Techlog64 2015.3 (r158051), both from Schlumberger.

The Stratigraphic Lexicon of Cuba (IGP, 2024) allowed specifying the ages of the geological formations and updating the nomenclature of several taxa, where the facies drilled in the wells and the corresponding lithological designations were classified (Pérez-Peña *et al*., 2024).

New lithostratigraphic columns of the aforementioned wells were elaborated and stratigraphic schemes were constructed to support the results (González-Leyva, 2023; González-Leyva *et al*., 2025). The Wilson (1975) Standard Microfacies Model was used to place the well sequences.

3. RESULTS AND DISCUSSION

The results of the analysis of the facial variability of the sediments of the Vega Alta Formation reveal its complex nature; its deposition occurred in a Paleogene foreland basin, where orogenic processes played an important role. The infilling of this basin is very complicated, given by the rapid changes in facies, transverse and longitudinal, caused by the different phases of tectonic activity (Morales-Echeverría *et al*., 2021).

The data obtained in the research responded to a multidisciplinary assessment to characterize the facial variability of the Vega Alta Formation (González-Leyva, 2023).

3.1. Results of the drilling analysis

Well *Long Year 1*

Well *Long Year 1* was drilled in 1954. Coordinates 22° 21' 27.637656" N and -79° 39' 53.661461" W, to a depth of 186 m. Ten cores were cut that provide lithological and paleontological information of the drilled units (Figure 2).

0-185 m: White, clayey limestone, in parts fractured, silicified, gray to beige; shale, fractured, clayey, dark gray to beige; calcareous sandstone, polymictic, fine to medium grained, light gray to white, with igneous grains, clay, and conglomerate intercalations; limestone with breccia, dark gray to black.

The documented sequence corresponds to the Vega Alta Formation, of Late Paleocene-Early Eocene age, with redeposition from the Campanian-Maastrichtian, represented by: *Globotruncanita stuarti, Globotruncana lapparenti, Archaeoglobigerina cretacea*, miliolids, *Orbitoides* sp., *Pseudorbitoides* sp., rotaliids, *Cosinella* sp., as well as from the Late Jurassic, Late Tithonian, defined by: *Nannoconus* sp. (2) and radiolarians (*Meyanella* sp.).

Well *Long Year 1A*

Well *Long Year 1A* was drilled in 1954. Coordinates 22° 21' 26.688245" N and -79° 39' 56.816437" W, with a final depth of 396 m. Fifteen cores were cut from which lithological and paleontological information was obtained.

Figure 3 reflects the updating of the microfossil record systematics and lithological terms, as well as the stratigraphic interpretation of the drilled section.

0-387 m: Limestones, fractured and breccias with some shale and chert, fragments of clayey limestone, shale, dense green limestone, calcite veins, clay, calcareous claystone, silicified sandstone, fractured. In this interval there is redeposition from the Turonian-Maastrichtian, represented by: *Archaeoglobigerina cretacea, Thalmanninella appenninica, Globotruncana lapparenti, Schackoina* sp. In cores 13 and 14 (335.28-387.09 m) they correspond to a breccia zone. The documented sequence corresponds to the Vega Alta Formation.

387-396 m: Igneous rocks, probably volcanic, finely crystalline, partly cataclastic; found in cores 15 and 16. Assigned to the ophiolitic mélange. The age is indeterminate due to the very scarce presence of microfossils.

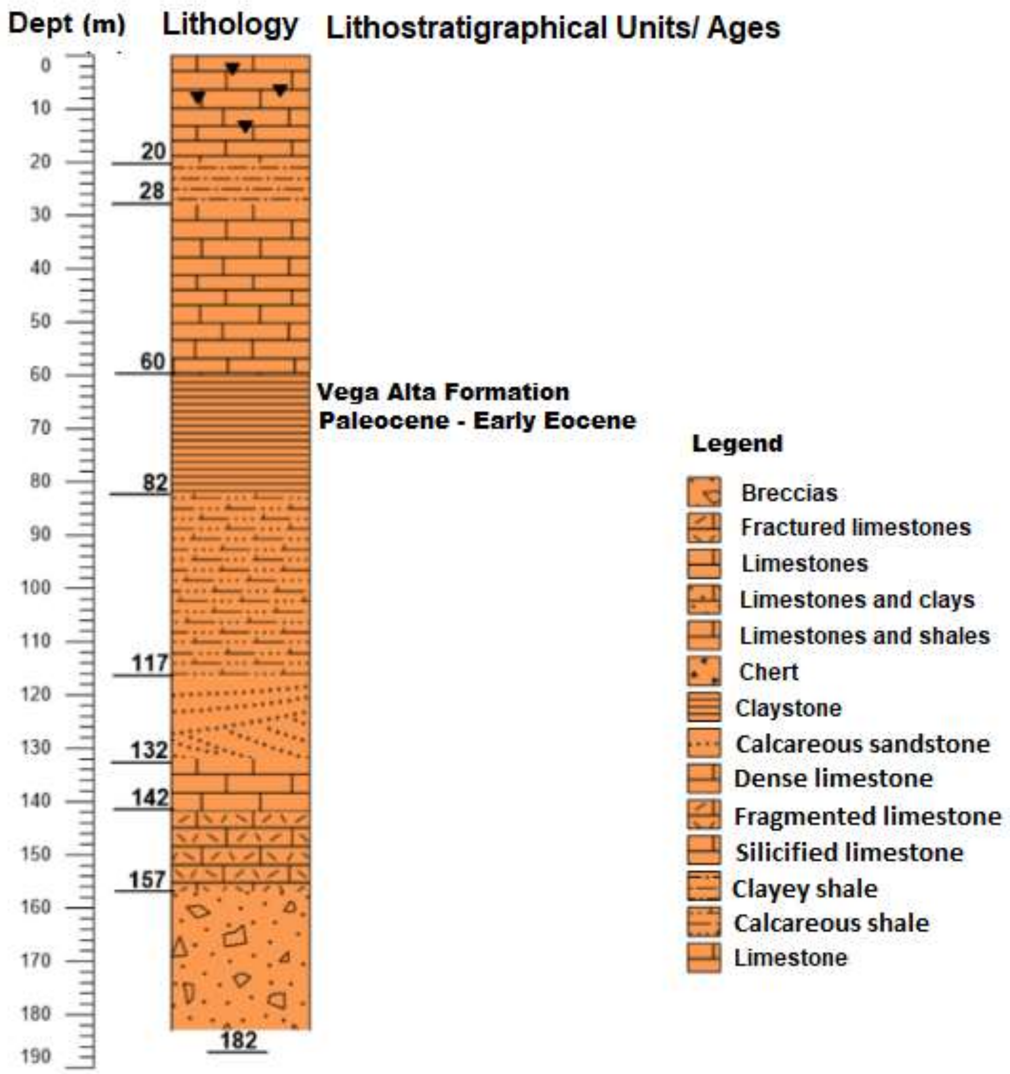

Figure 2. Lithostratigraphic column of well Long Year 1.

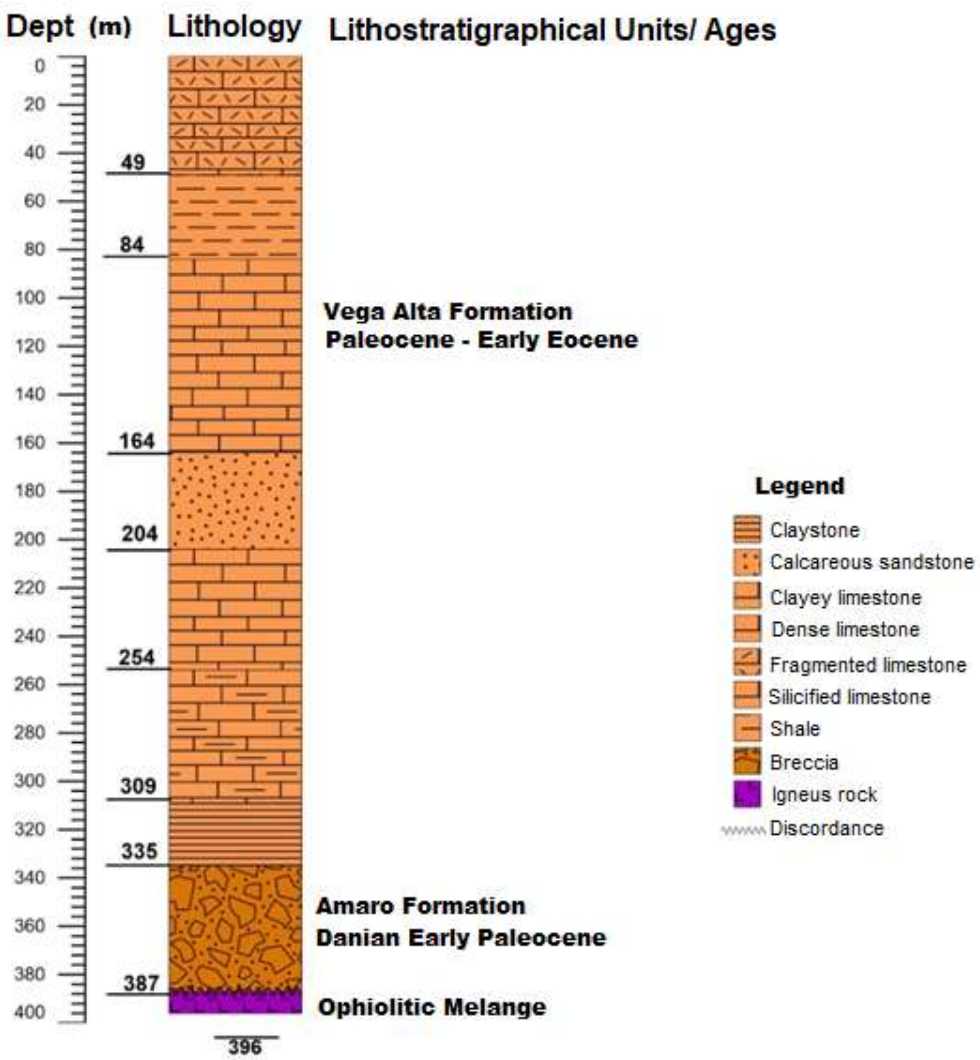

Figure 3. Lithostratigraphic column of well Long Year 1A.

Well *Long Year 2*

Well Long Year 2 was drilled in 1954. Coordinates 22° 19' 13.501157" N and -79° 38' 52.735838" W, final depth is 397 m. Twenty-four cores were cut, providing lithological and paleontological information. For the reanalysis of this well, data were integrated, systematics and ages were updated, leaving the section as shown in Figure 4.

0-296 m: Serpentine, black, greenish, with green crystals, highly brecciated with slickensides, corresponding to the Ophiolitic Mélange (cores 1-14). No fossils were found.

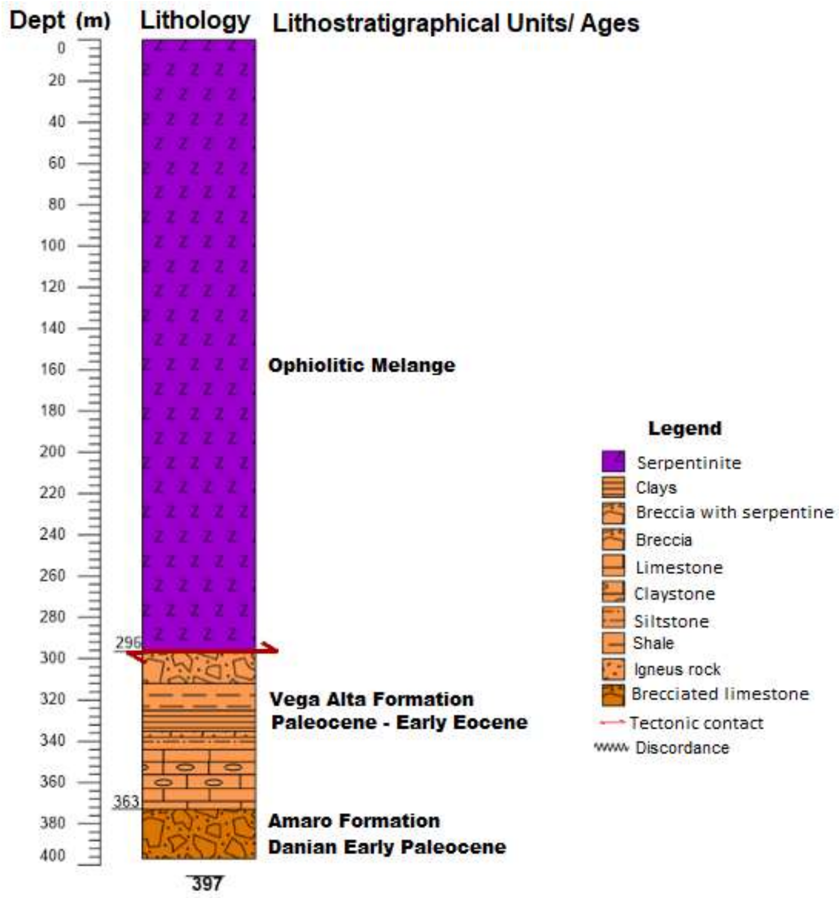

Figure 4. Lithostratigraphic column of well Long Year 2.

296-363 m: Polycomponent chaotic sequence, with green serpentinite grain breccias, black shale with clayey matrix, and fragments with calcareous material, light brown shale, medium hardness, fissile, fragile with slickensides (cores 15-20); grayish green serpentine and igneous rocks, with some milky white grains; calcareous siltstone, gray, brecciated, with calcite veinlets and some limestone fragments; light brown claystone, hard, fractured, with slickensides. Microfossils found were scarce and redeposited (reworked entities, according to Fernández-López, 2000). Archaeoglobigerina cretacea and Guembelina sp., taxa belonging to the Late Cretaceous, appear. These mixed lithologies, with sand-clay facies, are correlated with the Vega Alta Formation.

363-397 m: Fragmentary limestones, some dense with bitumen in parts, with fine veinlets filled with calcite; with very brecciated dark gray cherts.

The reported planktonic foraminifera, Archaeoglobigerina cretacea and Guembelina sp., date these sediments as Albian-Maastrichtian. Thalmanninella appenninica appears for the first time at the end of the well, which is considered a reworked entity (Fernández-López, 2000) (cores 21-24). This brecciated sequence is assigned to the Amaro Formation, of Early Paleocene Danian age (González-Leyva, 2023).

Well *Sullivan* 6

Well *Sullivan* 6 was drilled in 1954, located 2.8 km from the old Santa Teresa Sugar Mill, Villa Clara province, with a final depth of 915 m. Coordinates 22° 21' 28.739542" N and -79° 40' 9.031134" W. Twenty-nine cores were cut, which provided lithological and paleontological information. The well section is shown in Figure 5.

0-18 m: Not recorded. According to the geological map, the section began in the Vega Alta Formation.

18-915 m: Dense, fragmentary, brecciated and partly silicified limestone, gray; some black, pink, pastel green and cream; gray, black and light brown chert. Very fine-grained calcareous sandstone, with igneous elements. Calcareous shale, black and soft; light brown clay and some siltstone.

Paleogene microfossils described in the well are scarce, only *Globigerina* sp. (cores 13 and 15) was recorded, also *Guembelina* sp. (a genus that has undergone many changes, so it was decided to take the age from the Heterohelicidae family). As is common, this formation contains numerous olistoliths with fossils of Cretaceous ages, such as: *Archaeoglobigerina cretacea*, *Globotruncana* sp., *Meyenella* sp., *Hastigerinoides* sp., *Schackoina* sp., *Nannoconus* sp., *Oligostegina* sp., *Pseudorbitoides* sp., *Sulcoperculina* sp., *Vaughanina* sp., *Torreina* sp. and miliolids; an assemblage considered redeposited, composed of "reworked entities" from a taphonomic point of view (Fernández-López, 2000).

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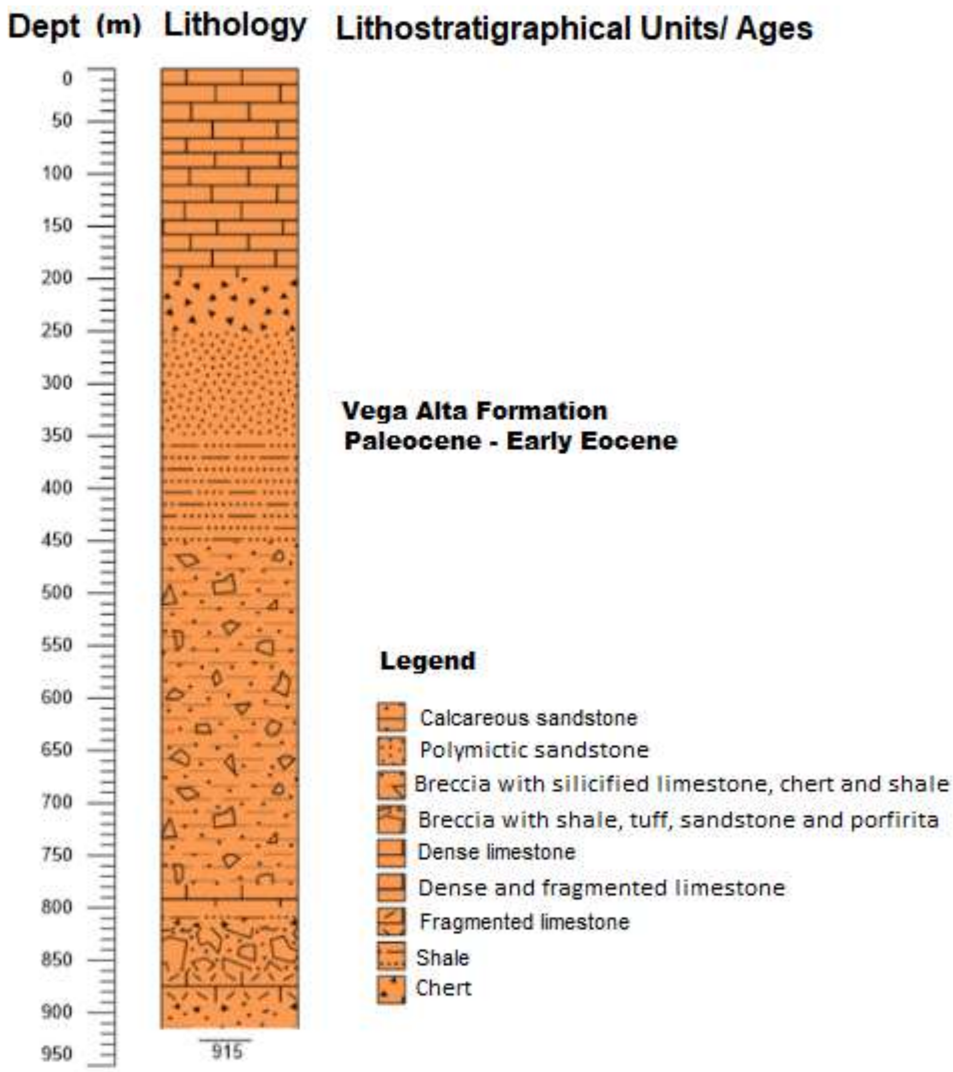

Figure 5. Lithostratigraphic column of well Sullivan 6.

From core 26 (814-825 m), the presence of a reverse fault is evident, located above a chaotic breccia zone, containing tuffite with clay, gray and dark gray shale; calcareous sandstone (calcarenite) and calcareous claystone, dark gray.

After the breccia zone, another interval of limestone with sandstone intercalations, with grains of igneous rocks, shale and cherts appears again. It is assumed that the entire well cuts only sediments of the Vega Alta Formation, given the described lithological mixture of Paleocene-Early Eocene age.

For well Sullivan 6, the electrofacies (EF) were analyzed taking into account the lithologies described and paleontological data revealed by the cores. The division of the section according to the existing log is represented in Figure 6 and the electrofacies are described below.

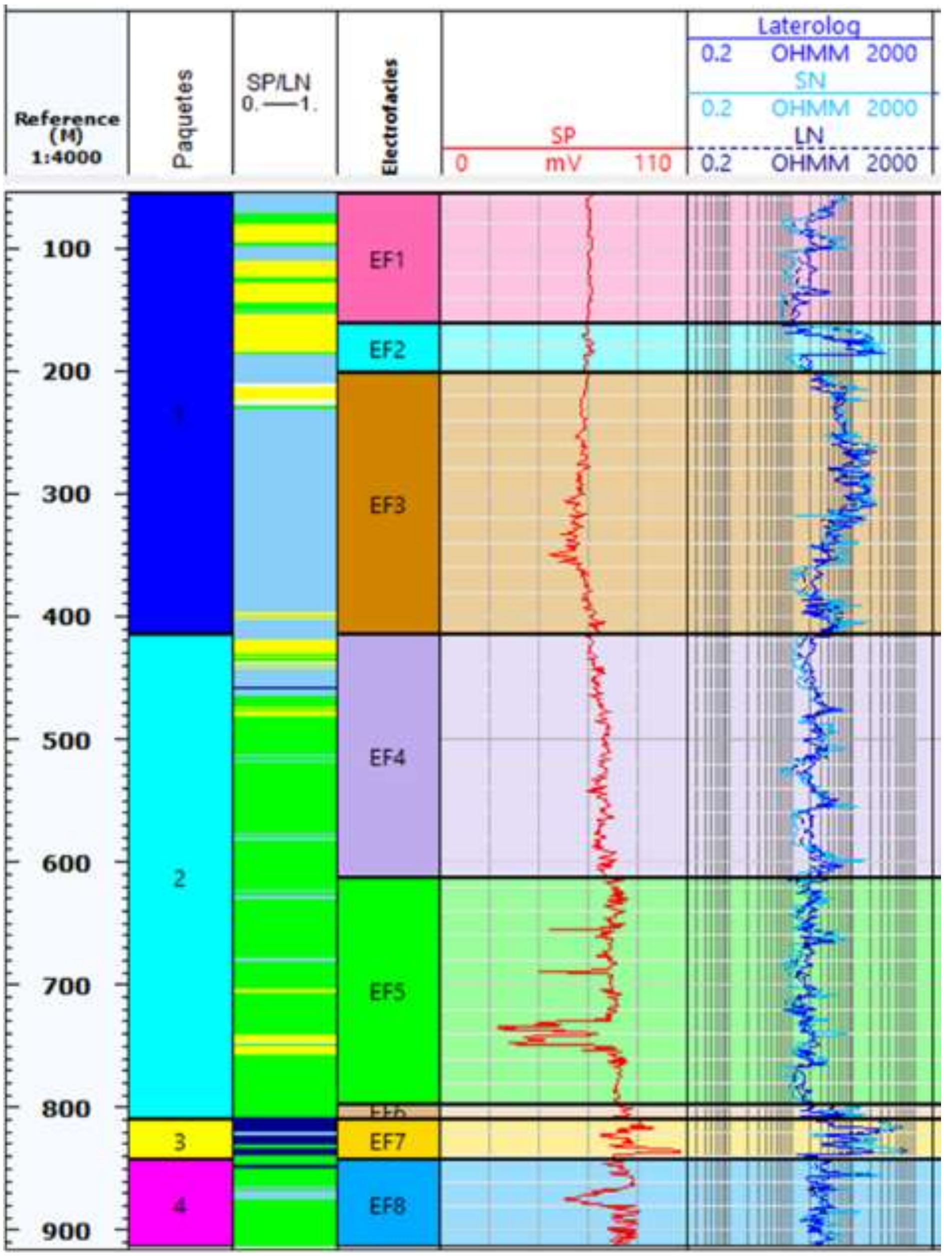

Figure 6. Composite log with color differentiation for lithological variety. Well Sullivan 6.

EF 1 (55.00 m–164.00 m)

Heterogeneity in the logs, where resistivity is low to medium, reaching values ranging between 9 ohm-m to 20 ohm-m, thus some intercalations of clayey components are evidenced, marked by lower resistivity values. SP (spontaneous potential) with medium values, not marking the baseline, which

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may correspond to various lithologies as described. Carbonate, clayey-sandy sequence.

EF 2 (164.00 m–202.30 m)

This is essentially carbonate, with high resistivity values, which is associated with hard limestone, although a slight decrease in values is observed towards the base of the interval, indicating that it becomes more clayey at depth. The SP maintains the behavior of the previous EF. Predominantly carbonate sequence with cherts.

EF 3 (202.30 m–360.00 m)

Resistivity varies from around twenty at the top, to reaching values greater than 100 ohm-m from the center to the base of the interval; significant change in the SP, as it behaves with very small, but numerous deflections, and with lower values than EF 2. This behavior suggests the presence of predominantly carbonate rocks, with fine siliceous and clayey intercalations, which is seen in track 3, generated from the cross-plot of the log. Siliceous-clayey, carbonate sandy sequence.

EF 4 (360.00 m–667.00m)

Small change in SP with higher values than EF 3, but not reaching the clay baseline, it remains with small deflections associated with different lithologies. Drop in resistivity values (8 ohm-m to 30 ohm-m), associated with clayey, sandy and, to a lesser degree, carbonate intercalations. Flyschoid clayey-sandy carbonate sequence.

EF 5 (667.00 m–796.25 m)

It is essentially clayey. In general, the lowest resistivity values of the entire section are observed, however marked fluctuations are seen in the curves, given by intercalations of other rock types. The SP, although it reaches the clay baseline, has peaks towards lower values, supporting this criterion and evidencing a sandy interval, confirmed in track 3. Olistostromic clayey sequence.

EF 6 (796.25 m–809.00 m)

Resistivity increases relative to EF 5, basically carbonate, but revealing intercalations of other rocks; the SP remains on the clay baseline.

EF 7 (809.00 m-838.50 m)

Resistivity is the highest of the entire section, indicating the presence of a very hard rock. The spontaneous potential also reaches very high values, which is not characteristic in its readings; here an affectation by tectonics and influence of igneous rocks is assumed. Olistostromic sequencelistostrómica.

EF 8 (838.50 m–915.00 m)

Evident drop in resistivity in relation to the previously described EF, although it maintains medium values associated with carbonates or sandstones; the spontaneous potential supports this criterion, but revealing, by high values, the presence of clay. Clayey olistostromic sequence.

In the geophysical logs of well Sullivan 6, a mixture of different lithologies is observed, composed of calcareous sandstone exhibiting low to medium resistivity, with medium to low spontaneous potential (SP); limestone with medium SP and high resistivity values, and clayey rocks possessing low to medium resistivities, with high spontaneous potential values.

The log and the electrofacies division is coherent with the rather flyschoid character exhibited by the section drilled by well Sullivan 6. Some inflections are associated with breccia zones, presumably related to tectonic manifestations.

3.2. Esquemas texturales

The updating of bioevents, stratigraphic ranges and the elaboration of the columns allowed the preparation of textural schemes (Figures 7 to 10), for a better expression of facial variability in the Placetas sector.

Figure 7 shows the facial variability according to well Long Year 1, represented by eight lithofacies of different compositions. The sequences show a very varied lithological constitution, representing the olistostromic part of the unit, with a clayey-sandy matrix. These conditions led to the redeposition of limestone clasts of Cretaceous-Jurassic ages, with polymictic sandstone, shale and cherts.

This fraction is interpreted as the result of redeposition processes produced through turbiditic currents, coming from very productive source areas given the tectonic dynamics of the moment on the active margin of that basin. This also explains the variable composition and poor sorting of the grains throughout the section drilled by this borehole.

Note the variation in dip of the lithological packages in different intervals, with angles from 40º-45º, but reaching at different depths, up to 60º-70º. This variation in dip reflects the folding and faulting, with fracturing and fragmentation, to which the general sequence was subjected during tectonic emplacement in the final orogeny.

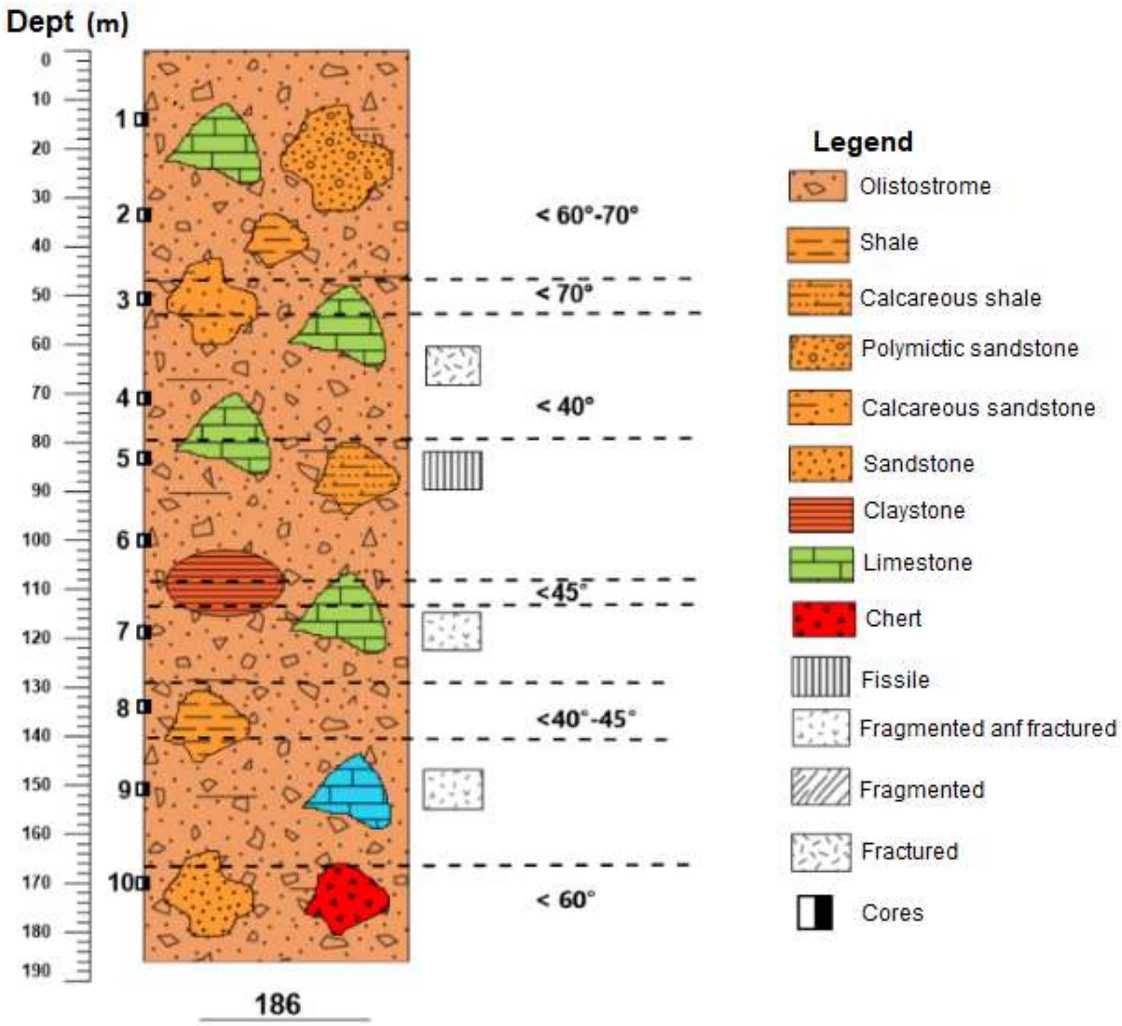

Figure 7. Textural scheme of well Long Year 1.

The textural scheme of Long Year 1A (Figure 8), shows some seven lithofacies of varied composition. The sediments express their olistostromic character, with redeposition of polymictic clasts and olistoliths in a clayey-sandy matrix. Associated with this high dynamic process in the basin are unsorted detrital redeposition and matrix-supported texture, as well as taphonomic reworking of fossil entities during the action of turbidity currents. A provenance is deduced from a source area constituted by complex sequences of Jurassic-Cretaceous ages, located relatively nearby.

The dips of the various verified lithological packages are relatively steep, at 50º-70º. A high variation of textures due to brittle deformations is noted. The overthrusting of the allochthon and the tectonic emplacement of the unit over the ophiolites are also deduced, as processes producing the aforementioned features.

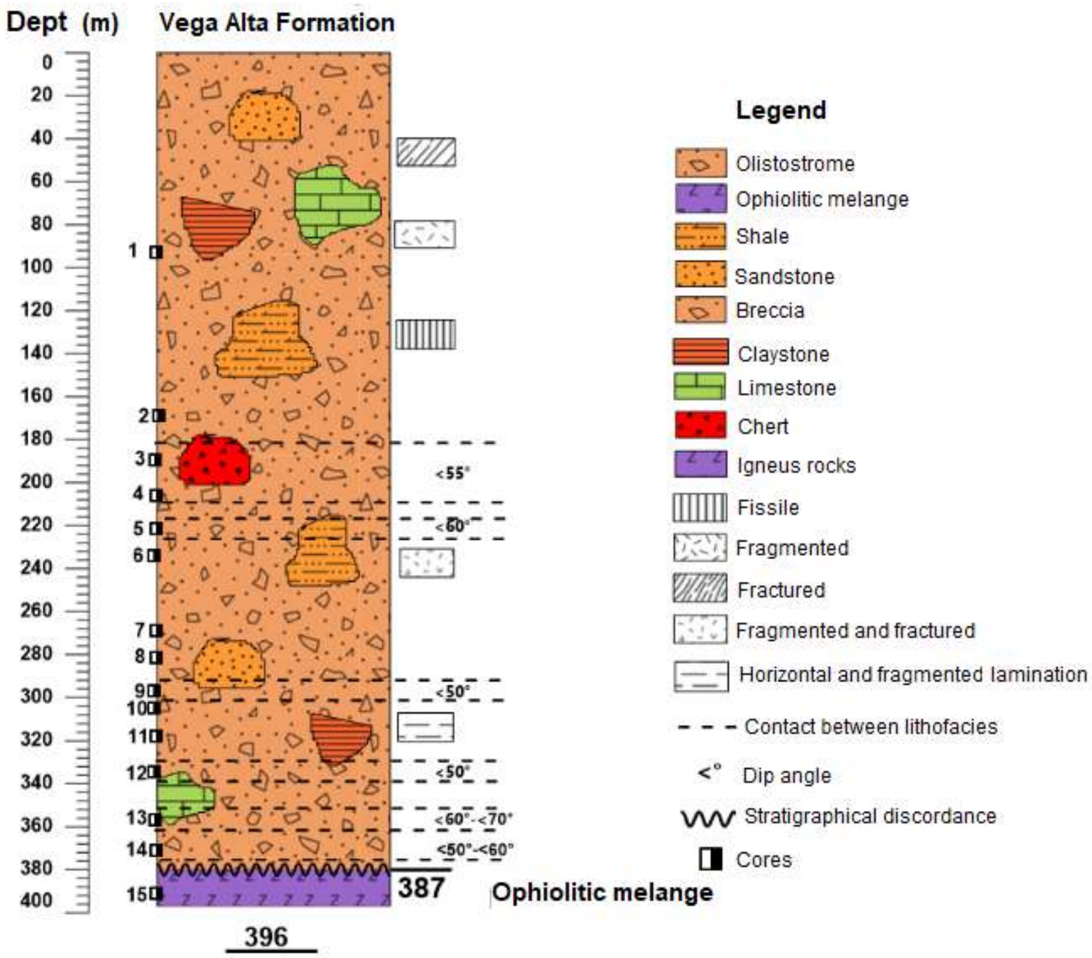

Figure 8. Textural scheme of well Long Year 1A.

The textural scheme of well Long Year 2 (Figure 9) evidences the verified facial variability for the unit. In this section, unlike the previous ones, the Vega Alta Fm. lies beneath the allochthonous ophiolites; underlying these, the Amaro Fm. is distinguished, which represents the K-Pg deposits in the CNPB (Rojas-Consuegra & De Huelbes, 2021; Rojas-Consuegra *et al*., 2021). The unit here is composed of eight lithofacies, in the chaotic olistostromic sequence, with varied clasts in a clayey-sandy matrix.

The angles measured in the drill cores range from 40º-80º, showing the intense dislocation present, which may be due to olistostromic accumulation, but also induced by synorogenic tectonic processes during the emplacement of the overthrust allochthonous sheets covering the unit.

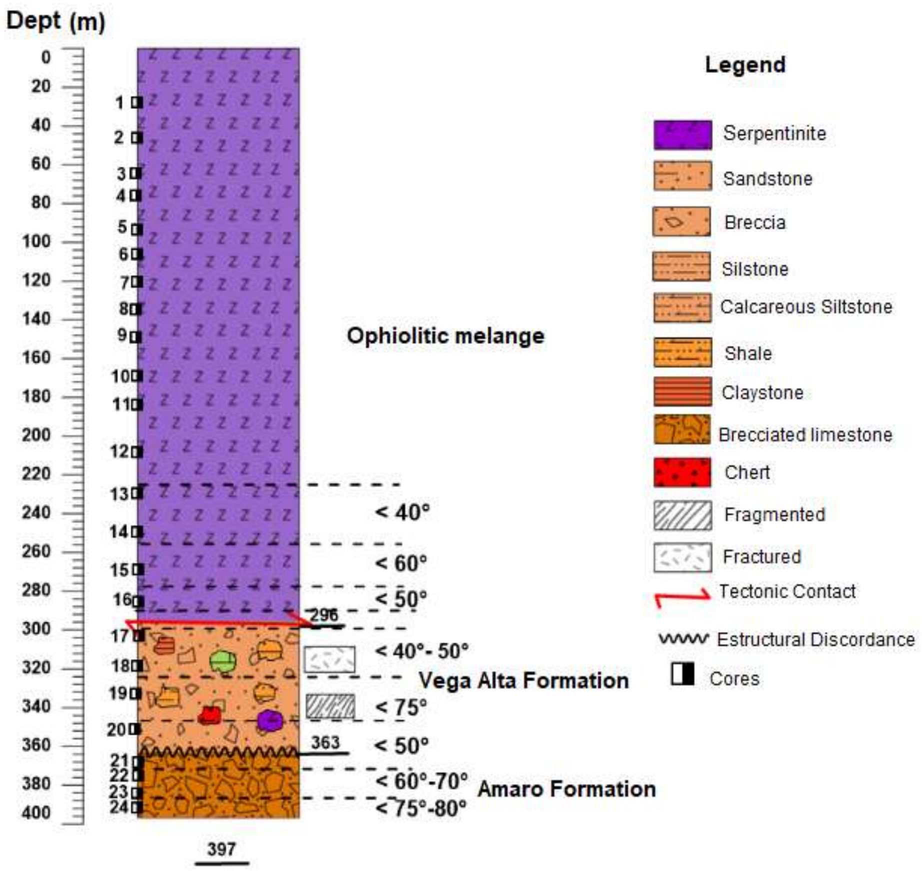

Figure 9. Textural scheme of well Long Year 2.

The textural scheme of well Sullivan 6 (Figure 10) represents a somewhat different facial variability from the previous sections. This variability is manifested by numerous cycles of intercalations of limestone, shale and cherts. The last lithofacies is represented by radiolarian silicites or radiolarites, due to silica enrichment given by the high content of fossil radiolarians it contains. These olistoliths are considered to have greater thickness towards the lower part of the well.

Dip angles range from 40º-85º, corresponding to contacts between lithofacies or by natural disposition, due to faults or folding. These show the tectonic structure of the section, with steeper surfaces in the lower part, decreasing upwards.

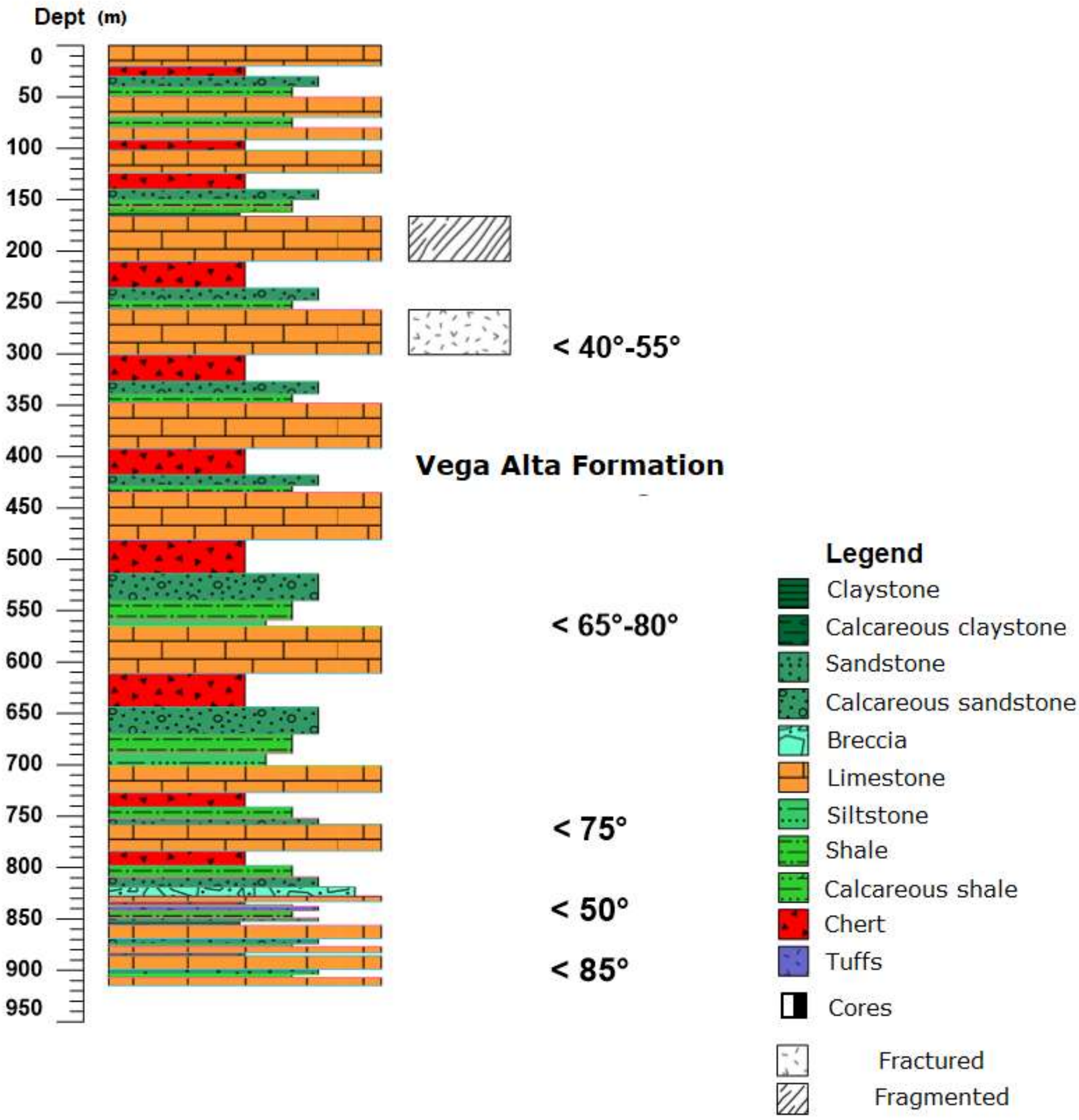

Figure 10. Textural scheme of well Sullivan 6.

3.3. Correlation between wells

The correlation between the sections drilled by the restudied wells is a very complex exercise; it relies on the textural schemes to manifest the possible relationships. Furthermore, an interpretation of the paleoenvironment in which the identified facies and the sequences they integrate accumulated is attempted. The textural schemes (Figure 11) of three wells (Sullivan 6, Long Year 1 and 1A) were correlated. Correlation with well Long Year 2 was not possible, because it is distant, south of the study area.

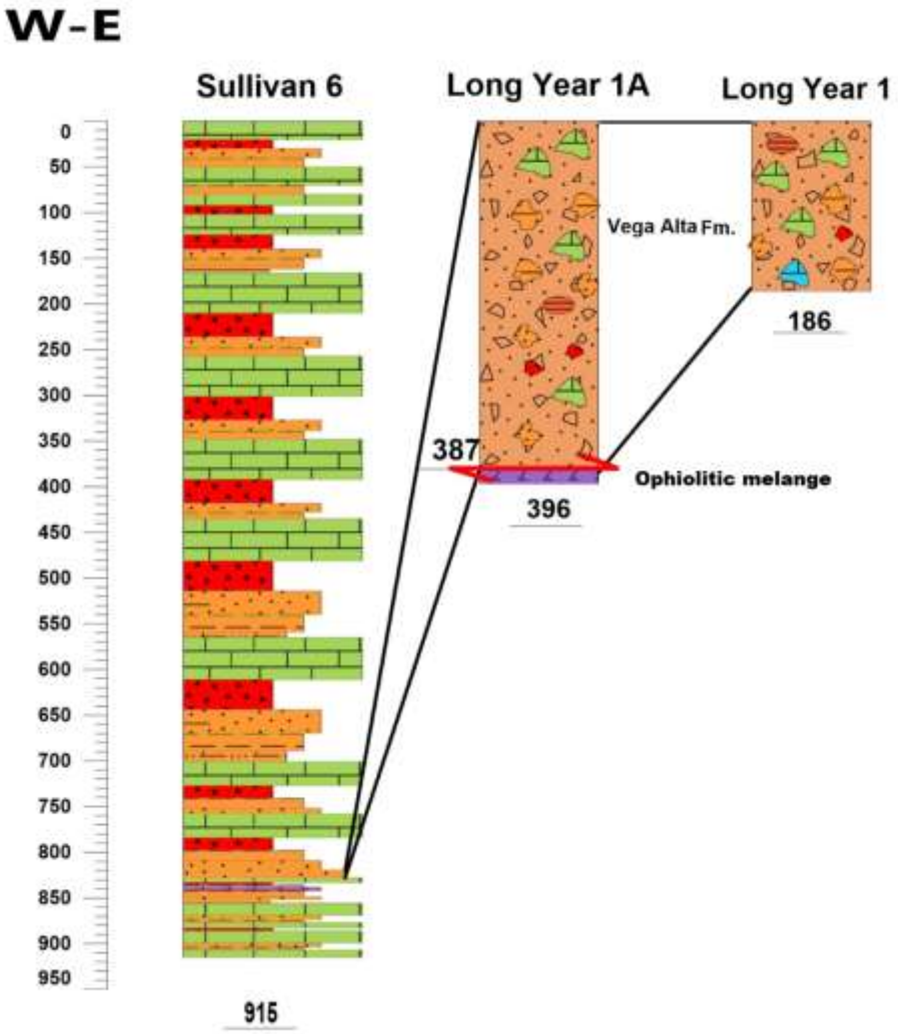

Figure 11. Correlation of textural schemes between wells Sullivan 6, Long Year 1A and Long Year 1 (east-west direction).

In well Sullivan 6, located west of wells Long Year 1, 1A, a polycomponent olistostromic level appears in a clayey-sandy matrix, including blocks and olistoliths of limestones from ancient sequences, fundamentally Cretaceous-Jurassic, also carbonate breccias, with calcarenite, silicite, siliceous clayey rocks, sandstone, serpentinite; metamorphic and volcanic rocks, which predominate towards the base of the section, as evidenced in the geophysical log.

It is confirmed that lithofacial changes are very abrupt and over short distances within the Vega Alta Formation, which is typical of synorogenic olistostromic units in Cuba, and which are generally related to the mélange at a regional level. This result is in accordance with the sedimentological model established for this unit (Morales-Echevarría, 2021).

3.4. Paleoenvironment interpretation

The interpretation of the paleoenvironment to which the studied sequences were associated during the synorogenic infilling processes of the basin, was carried out from the study of the lithofacies and biofacies of the Vega Alta Formation, applying the Wilson Model (1975), modified by Flügel (2004). The facies in the unit in the analyzed wells generally correspond to facies belts numbers 3 and 4:

FB-3 (Slope Base): Facies drilled by well *Sullivan* 6, formed by platform material, predominantly reworked and containing pelagic elements.

FB-4 (Slope): Facies drilled by wells *Long Year 1*, *Long Year 1A* and *Long Year 2*, constituted by pelagic material, mixed with fine detritus, detached from adjacent shallow platforms.

The fragments offer a very varied provenance from the rocks of the North American Continental Margin from the Late Jurassic, Middle Cretaceous to the Campanian--Maastrichtian, and contributions from the Cretaceous Volcanic Arc and its cover.

This allows inferring the presence of fragments of allochthonous nature (components derived from other ancient basins). This fact is associated with gravitational mass slides, such as debrites and turbidites of rocks originating from a very active margin, which was undergoing intense tectonic activity and uplift (Morales-Echevarría, 2021).

4. CONCLUSIONS

- In the Placetas sector, Villa Clara, 12 lithofacies are identified in the Vega Alta Formation, through the detailed study of the sequences drilled by wells Long Year 1, Long Year 1A, Long Year 2 and Sullivan 6.

- Two large heterogeneous groups of sediments affected by tectonics are determined in this unit: the first of olistostromic nature, and the second, of carbonate-siliceous-clayey nature. A chaotic, polycomponent olistostromic sequence is evidenced towards the upper part, with olistoliths containing Cretaceous-Jurassic fossils, and the carbonate-siliceous-clayey package towards the lower part.

- The updating of the nomenclature, systematics and chronostratigraphy of the bioevents of the fossil record of the Vega Alta Formation has allowed verifying its age as Paleocene to Early Eocene, although with abundant older fossils, of Jurassic--Cretaceous age (reworked entities).

- It is confirmed that in this unit lithofacial changes are very abrupt and over short distances, which is typical of synorogenic olistostromic units in Cuba and are generally related to the origin of the mélange at a regional level.
- The facies and sequences in the studied sections of the analyzed wells correspond to facies belts 3 and 4 of the Wilson Model: wells Long Year 1, Long Year 1A and Long Year 2 are located in FB-4 of the platform slope; and well Sullivan 6, in FB-3 of the slope base.

5. REFERENCES

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Additional information

Conflict of interest

The authors declare that there are no conflicts of interest.

Author contributions

LGL: Bibliographic search of selected wells. Analysis of compiled data. Preparation of the geological scheme using Argic software. Elaboration of lithostratigraphic columns, textural schemes and correlation between wells using Strater software. Interpretation and integration of information, writing, revision and editing of the article. **RRC**: Analysis of compiled data together with interpretation and integration of information, writing, editing and revision of the article. **MVPP:** Analysis of compiled data together with interpretation and integration of information, writing, editing and revision of the article. **MTD:** Analysis of compiled data for geophysical interpretation of selected wells. Petrophysical analysis. **LFC:** Analysis of compiled data together with interpretation and integration of information and revision of the article.

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