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LITHOFACIES AND PALAEOENVIRONMENTAL INTERPRETATION OF THE TURBIDITE SEQUENCE IN THE CHONOS ARCHIPELAGO, SOUTHERN CHILE.

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RESUMEN

La medición detallada de siete secciones estratigráficas en una secuencia turbidítica que aflora en el Archipiélago de los Chonos, permitió reconocer las siguientes siete litofacies: F1= Areniscas gruesas y muy gruesas, F2= Areniscas gradadas de grano grueso y medio, F3= Areniscas macizas, F4= Areniscas con estratificación paralela, F5= Areniscas finas y fangolitas interestratificadas, F6= Fangolitas y chert interestratificados, F7= Depósitos perturbados. Se les interpreta como turbiditas marinas de aguas profundas que representan ambientes de depositación internos a medios (F1, F2, F3), medios a externos (F3, F4) y de fondo de cuenca (F5 y F6), en un abanico de depositación turbidítica. Estas rocas fueron incorporadas al prisma de acreción del sur de Chile antes del Cretácico.

ABSTRACT

The detailed measurement of seven stratigraphic sections in a turbidite sequence which crops out in the Chonos Archipelago, allowed the recognition of the following seven lithofacies: F1= Pebbly sandstones, F2= Coarse to medium-grained sandstones, F3= Massive medium-grained sandstones, F4= Parallel-bedded fine to medium-grained sandstones, F5= Interbedded fine-grained sandstones and mudstones, F6= Interbedded mudstones and chert and F7= Disrupted deposits. They are interpreted as deep water marine turbidites representing inner to middle (F1, F2, F3), middle to outer (F3, F4), and basin floor (F5 and F6) depositional settings within a turbidite fan system. These rocks were incorporated into the accretionary complex of the southern Chile continental margin in pre-Cretaceous times.

INTRODUCTION

The Chonos Archipelago and adjacent areas (Fig. 1) are generally composed of a sequence of greenschist-bearing and greenschist-free sedimentary and metasedimentary rocks. Within the actual Chonos Archipelago, the metamorphic grade rises from SE to NW (Miller 1976, 1979). The sedimentary rocks were attributed to a submarine fan origin, but a comprehensive study of the sedimentology of this fan has been lacking until now. Miller (1976) and Hervé et al. (1981) described the rocks petrographically in detail.

Miller (1976, 1979) distinguished three tectonometamorphic zones that are characterized by different overprinting of fold structures and separated three non-formal formations. The SSE plunge of the fold structures shows in a generalized section along the fold axes, that the low grade greenschist bearing unit is older than the very low grade metamorphic zones in the SSE which exhibit the primary sedimentary structures.

As to the age of the strata, biostratigraphical data are very scarce in the Paleozoic basement of Chile. The discovery of poorly preserved brachiopods within the very weakly metamorphosed Potranca Formation (Miller & Sprechmann, 1978) suggested a probable Devonian age for the submarine fan deposits. However, recent determination of Late Triassic fossils from the same locality (Fang et al., 1998) imply that the sediment accumulation was active at that time. Devonian trilobites described by Fortey et al. (1992) from Buill in the northern part of the study area confirm the existence of a Devonian sea in the region. Rb-Sr isotope analyses (Godoy et al. 1984) from the Guaitecas Archipelago north of the Chonos Archipelago suggested to an Early Permian age of metamorphism and therefore a pre-Permian age of sedimentation of the units. The large scattering of the sample points within the errorchron shows that homogenisation of Sr isotopes was not effective within the sampled area. The relatively well defined initial ratio of about 0.707 shows that the material has a past crustal history.

Due to the generally SSE plunging fold structures, the greenschist-bearing unit should be older than the greenschist-free, very low grade metamorphic fossil-bearing unit showing sedimentary structures. There is no doubt that the development of the NNW striking main schistosity and associated fold axes is continuous within the whole area. A more detailed study of the sedimentary facies within the zones where primary structures have been preserved, may be useful for the underlying units as well.

In the following discussion we present our preliminary interpretations of the facies development within the turbiditic rocks of the Chonos Archipelago.

LITHOFACIES DESCRIPTION AND INTERPRETATION

The lithofacies description and interpretation presented below are based on the detailed measurement of seven stratigraphic sections (Figs. 2, 3, 4). Seven types of lithofacies were recognized, and each type was interpreted in terms of a specific depositional process. The sections were examined for bedding contacts, bed thickness and grain size

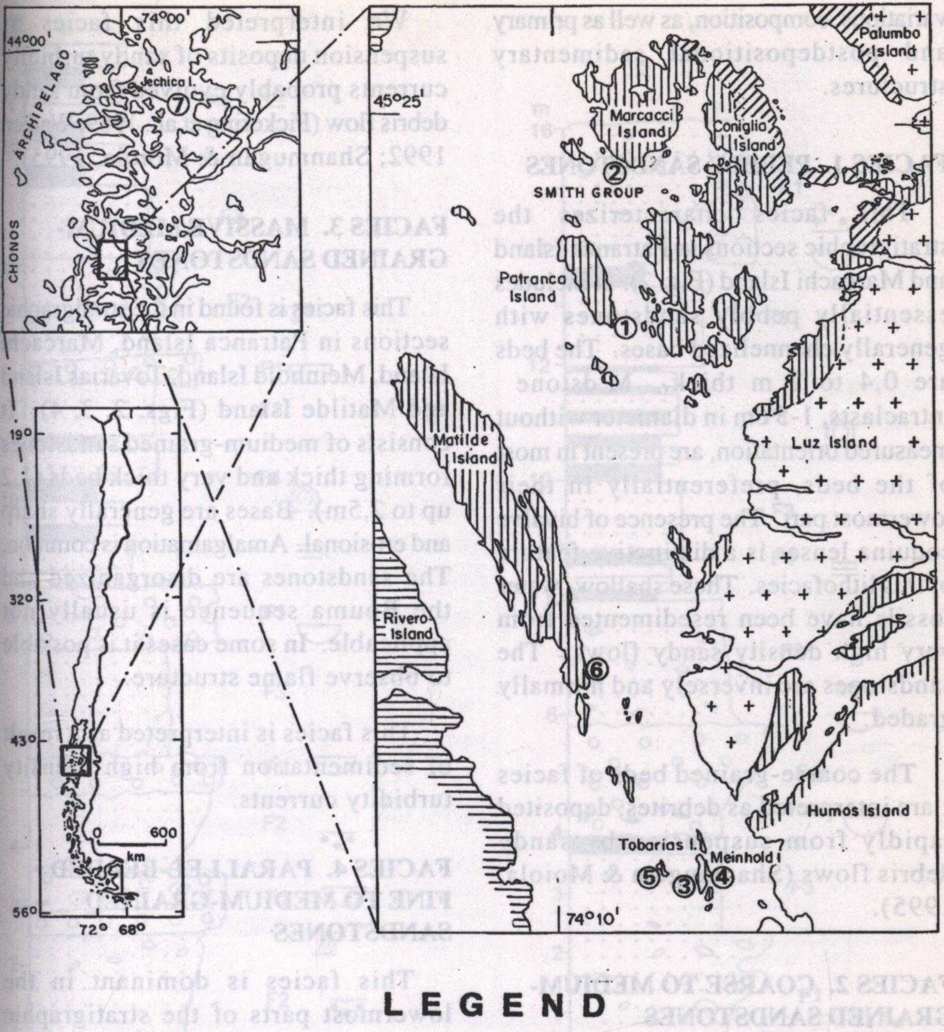

Figure 1. Location and geological map of the study area. Potranca Formation (Miller, 1976) is equivalent to the Potranca Unit (Godoy et al., 1984). The type locality is Patranca Island.

variations, composition, as well as primary and postdepositional sedimentary structures.

FACIES 1. PEBBLY SANDSTONES

This facies characterizes the stratigraphic sections in Patranca Island and Marcachi Island (Fig. 2). It includes essentially pebbly sandstones with generally channelized bases. The beds are 0,4 to 2 m thick. M dstone intraclasts, 1-5 cm in diameter without measured orientation, are present in most of the beds, preferentially in their lowermost part. The presence of bivalve coquina lenses is a distinctive feature of this lithofacies. These shallow- water fossils have been resedimented from very high density sandy flows. The sandstones are inversely and normally graded.

The coarse-grained beds of facies 1 are interpreted as debrites, deposited rapidly from suspension by sandy debris flows (Shanmugam & Moiola, 1995).

FACIES 2. COARSE TO MEDIUM-GRAINED SANDSTONES

This facies occurs in the stratigraphic sections in Patranca Island, Marcachi Island, Meinhold Island and occasionally Jechica Island (Figs. 2, 3, 4). It consists of coarse to medium-grained sandstones with scattered pebbles mainly in the upper part of the beds. The bed thickness varies from 0, 7 to 2,2 m. Mudstone intraclasts up to 2 cm across occur in the basal parts of the beds. Sedimentary structures include rare horizontal lamination, convolute bedding and the sandstones are inversely or normally graded.

We interpreted this facies as suspension deposits of sandy turbidity currents probably evolved from sandy debris flow (Pickering et al., 1989; Walker, 1992; Shanmugan & Moiola, 1995).

FACIES 3. MASSIVE MEDIUM-GRAINED SANDSTONES

This facies is found in the stratigraphic sections in Patranca Island, Marcachi Island, Meinhold Island, Tovarias Island and Matilde Island (Figs. 2, 3, 4). It consists of medium-grained sandstones forming thick and very thick beds (1,2 up to 2,5m). Bases are generally sharp and erosional. Amalgamation is common. The sandstones are disorganized and the Bouma sequence is usually not applicable. In some cases it is possible to observe flame structure.

This facies is interpreted as a result of sedimentation from high- density turbidity currents.

FACIES 4. PARALLEL-BEDDED FINE TO MEDIUM-GRAINED SANDSTONES

This facies is dominant in the lowermost parts of the stratigraphic sections in Tovarias Island, Matilde Island and the western coast of Meinhold Island and locally in Patranca Island (Figs. 2, 3, 4). It consists of fine- to medium-grained sandstones. The beds range from 0,5 to 1,8 m with an average thickness of 1 m. Most beds are horizontal laminated with sharp bases. Graded and convolute bedding are occasionally observed.

This facies is interpreted as the result of sedimentation from transitional high to low density turbidity currents.

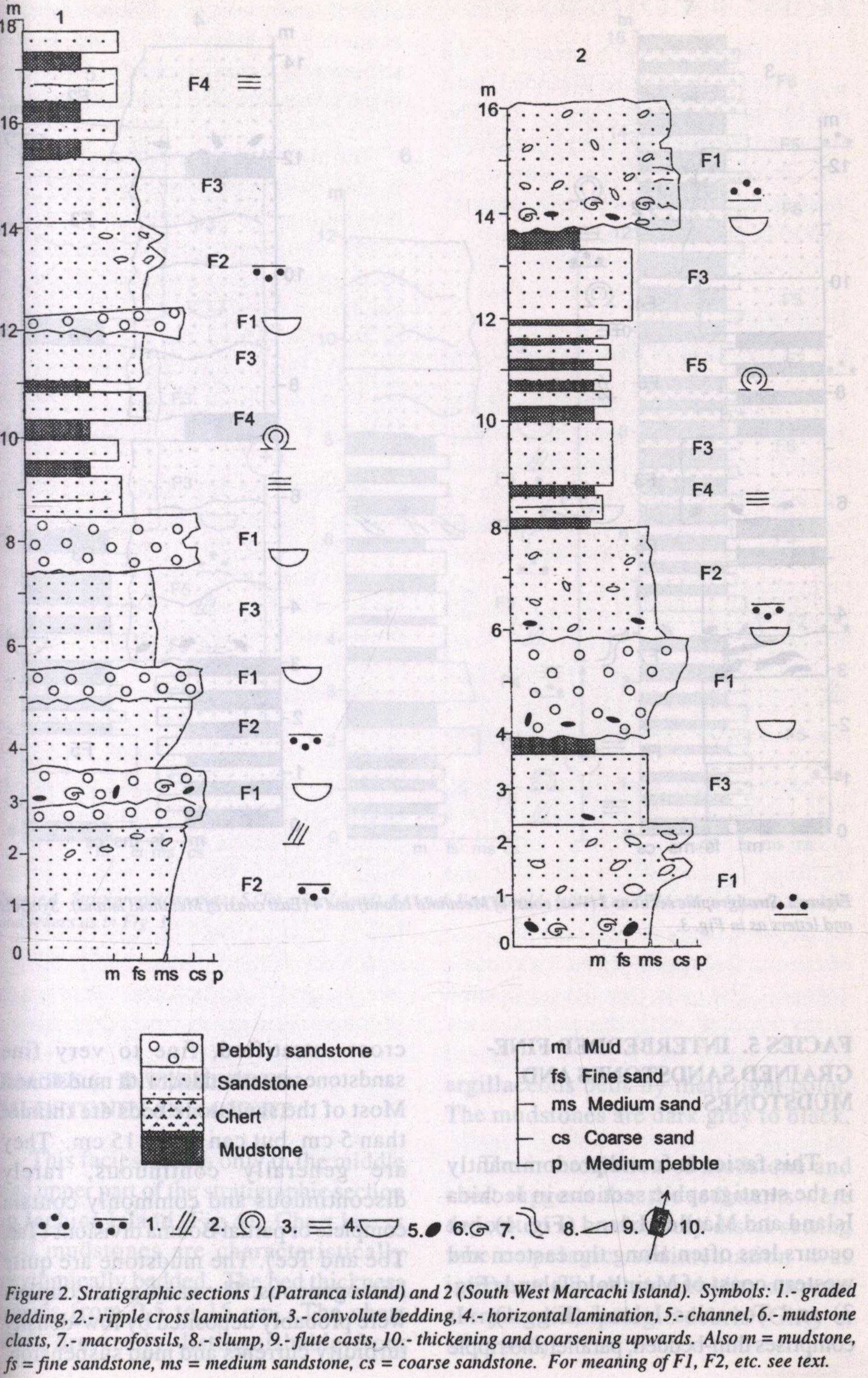

Figure 2. Stratigraphic sections 1 (Patranca island) and 2 (South West Marcachi Island). Symbols: 1.- graded bedding, 2.- ripple cross lamination, 3.- convolute bedding, 4.- horizontal lamination, 5.- channel, 6.- mudstone clasts, 7.- macrofossils, 8.- slump, 9.- flute casts, 10.- thickening and coarsening upwards. Also m = mudstone, fs = fine sandstone, ms = medium sandstone, cs = coarse sandstone. For meaning of F1, F2, etc. see text.

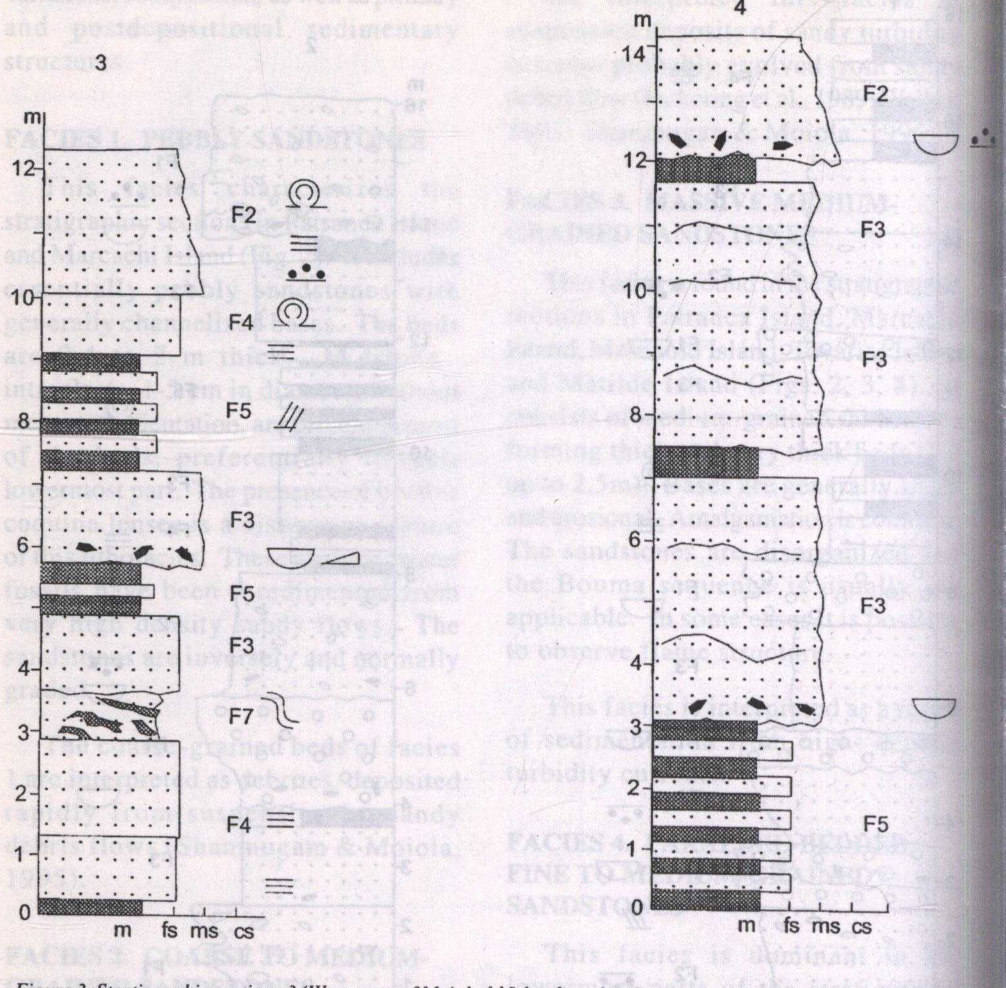

Figure 3. Stratigraphic sections 3 (West coast of Meinhold Island) and 4 (East coast of Meinhold Island). Symbols and letters as in Fig. 3.

FACIES 5. INTERBEDDED FINE-GRAINED SANDSTONES AND MUDSTONES

This facies is found predominantly in the stratigraphic sections in Jechica Island and Matilde Island (Fig. 4), but occurs less often along the eastern and western coast of Meinhold Island (Fig. 3) and Tovarias Island (Fig. 4). It comprises thin-bedded, parallel and ripple cross- stratified, fine to very fine sandstones interbedded with mudstones. Most of the sandstone beds are thinner than 5 cm, but can reach 15 cm. They are generally continuous, rarely discontinuous and commonly contain complete or partial Bouma divisions (Tae, Tbe and Tce). The mudstone are quite homogeneous. The sand-mud couplets were probably deposited by low-density turbidity currents and mud suspension.

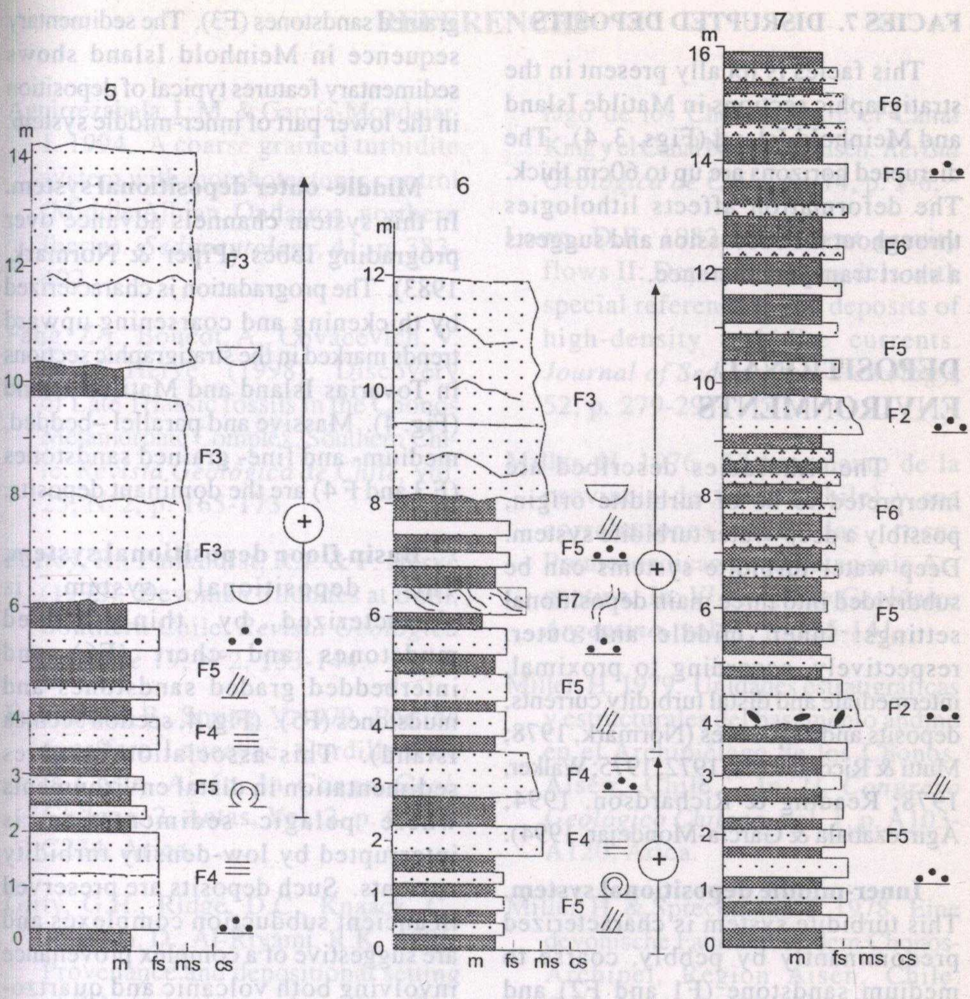

Figure 4. Stratigraphic sections 5 (Tovarias Island), 6 (South East Matilde Island) and 7 (Jechica Island). Symbols and letters as in Fig. 3.

FACIES 6. INTERBEDDED MUDSTONES AND CHERT

This facies occurs only in the middle and upper part of the stratigraphic section in Jechica Island (Fig.4). Chert layers and mudstones are characteristically rhythmically bedded. The bed thickness varies from 0,5 to 15 cm. The chert beds are easily distinguishable from argillaceous beds by their light color. The mudstones are dark grey to black.

The intercalation of mudstone and chert suggests that the sediments were deposited in a relatively distal setting where pelagic sedimentation was interrupted by dilute turbidity currents carrying hemipelagic debris (Girty et al., 1996).

FACIES 7. DISRUPTED DEPOSITS

This facies is locally present in the stratigraphic sections in Matilde Island and Meinhold Island (Figs. 3, 4). The disrupted horizons are up to 60cm thick. The deformation affects lithologies throughout the succession and suggests a short transport distance.

DEPOSITIONAL ENVIRONMENTS

The lithofacies described are interpreted to be of turbidite origin, possibly a deep-water turbidite system. Deep water turbidite systems can be subdivided into three main depositional settings: inner, middle and outer, respectively, according to proximal, intermediate and distal turbidity currents, deposits and sequences (Normark, 1978; Mutti & Ricci Lucchi, 1972, 1975; Walker, 1978; Reading & Richardson, 1994; Agirrezabala & García-Mondejar, 1994).

Inner-middle depositional system. This turbidite system is characterized predominantly by pebbly, coarse to medium sandstone (F1 and F2) and massive sandstones (F 3). The commonly channelized bases indicate the presence of erosional channels filled with coarse deposits. The main channel association is represented with the sedimentary succession outcropping in Patranca Island and Marcachi Island (Fig. 2). The vertical variations of the facies do not show clear thinning or thickening upward trends. The thick coarse sandstones are overlain by thin-bedded turbidites.

In this system is included the association where the main channels divide into distributaries filled predominantly by massive medium-grained sandstones (F3). The sedimentary sequence in Meinhold Island shows sedimentary features typical of deposition in the lower part of inner-middle system.

Middle- outer depositional system. In this system channels advance over prograding lobes (Piper & Normark, 1983). The progradation is characterized by thickening and coarsening upward trends marked in the stratigraphic sections in Tovarias Island and Matilde Island (Fig. 4). Massive and parallel –bedded, medium- and fine- grained sandstones (F 3 and F 4) are the dominant deposits.

Basin floor depositional system. This depositional system is characterized by thinly-bedded mudstones and chert (F6) and interbedded graded sandstones and mudstones (F5). (Fig. 4, section Jechica Island). This association involves sedimentation in distal environments where pelagic sedimentation is interrupted by low-density turbidity currents. Such deposits are preserved in ancient subduction complexes and are suggestive of a complex provenance involving both volcanic and quartzo-feldspatic continental type sources (Girty et al., 1996). In the idealized trench depositional model interstratified chert and mudstones represent sedimentation oceanward of the trench axial channel (Girty et al., 1996).

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