Diagnostic features of volcanic and volcaniclastic rocks in seismic sections on the Continental Shelf of Cabo Frio Area, SE Brazil

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Abstract

The Continental Shelf of Cabo Frio Area, located in between Campos and Santos basins, has been affected by an important magmatic episode in the Upper Cretaceous and Lower Tertiary Sequences. The analysis of seismic reflections, in the work area, pointed to a set of diagnostic features that can lead to the identification of magmatic events and the distinction of intrusive from extrusive igneous rocks, as well as their intercalations with epiclastic sedimentary sequences. The volcano-sedimentary section in the Cabo Frio Area is characterized by sets of strong and discontinuous reflections, usually with a well defined top and poorly defined base, and by the presence of volcanic edifices (cones). Intrusive rock bodies, like sills and dikes, are less common and have a seismic response characterized by strong positive reflections with abrupt lateral limits associated to their tops. The sedimentary sequences that overlap this volcano-sedimentary section are not directly related to the magmatic pulses in the area, however the pulses affected the paleorelief of the seafloor, which controlled the turbiditic deposition.

Introduction

The Continental Shelf of Cabo Frio Area, located in between Campos and Santos basins, shows unique features in its tectono-sedimentary evolution as compared to other areas of these basins (fig. 1). The presence of a regular pattern of antithetic faults in the basement and in the post-rift sedimentary section, along with important magmatic events in the Upper Cretaceous and Tertiary Sequences, which climax took place in the lower portion of the Middle Eocene age, are some of these features (Oreiro, 2002). A brief description of the seismic signatures of these magmatic events is the main objective of this work.

Diagnostic features in the seismic sections

The volcano-sedimentary section in the Cabo Frio Area is characterized by sets of strong and discontinuous reflections, usually with a well defined top. The internal seismostratigraphic pattern of these sets may be described as irregular or chaotic. The base of the sequence is generally poorly defined, due to the fact that the intercalations of volcanic, volcaniclastic and siliciclastic rocks affect the transmissibility of the seismic energy through this interval.

Intrusive magmatic rocks (dikes and sills) originate strong positive reflections with abrupt lateral terminations. Sometimes these rock bodies have arched forms and are discordant in relation to the country rocks (fig. 2). The original forms of emplacement can be modified by halokinesis; in this case, complex patterns are formed were positive reflections are intercalated with negative ones originated from low interval velocity volcaniclastic rocks. Sometimes, positive reflections lie under negative ones related to siliciclastic turbidites, whose depositions were controlled by the palaeorelief of the volcano-sedimentary sequence, sometimes deformed by halokinesis.

Volcanic cones constitute a characteristic feature in the area; they were formed under submarine and subaerial conditions (Mizusaki and Mohriak, 1992), depending on their dimensions and on the palaeobathymetry of their formation. Previous works (Mohriak et al., 1990; Rangel et al., 1990 and Mohriak et al., 1995) have described this feature, which formation was initially attributed to the combination of volcanism and salt diapirism, to the vertical stacking of turbiditic mounds, to palaeorelief surfaces preserved by the Middle Eocene unconformity or even to problems on the seismic stacking processing routines available at the time of the first interpretations. The analysis of recent petrographic, seismic, gravimetric and magnetic data allows a better correlation of this feature to the magmatic events.

Volcanic edifices in the Cabo Frio Area are coeval when close to one another, as can be observed in some present volcanic archipelagos such as the Hawaian Islands, where similar volcanic processes occur. The volcanism related to the formation of the Hawaian Islands have been described by many authors (e.g. Leslie et al., 2002; Wessel and Kroenke, 1998; Wolfe et al, 1994; Davis et al., 2001; Hekinian et al., 1999, Holcomb et al., 1988; Lonsdale and Batiza, 1980; Bridges, 1996).

Generally strong positive reflections occur nearby the base of these cones. These reflections may come from subvolcanic dikes, as described by Sial and McReath (1984), or from older lava flows that formed the palaeoseafloor, over which the cones were built.

In order to distinguish volcanic edifices, built by extrusive magmatism, from shallow intrusions that are commonly associated with the main volcanic pipe (plugs and necks, for instance), it is important to analyse the terminations of the seismic reflections related to younger formations in detail. It is also mandatory to make petrographic analysis of the rock cuttings recovered from the wells that have sampled the volcano-sedimentary section, in order to describe the facies and consequently the formation processes (intrusions or submarine/subaereal extrusions). In the cases of later halokinetic deformation, the

seismostratigraphic analysis becomes more complex, due to the deformation of the overlapping siliciclastic formations along with the volcano-sedimentary sequence (fig. 3). Fig. 4 shows that the Middle and Upper Eocene sections onlap the volcano-sedimentary sequence. This seismic line is located in the NW part of the work area, where the deformation related to halokinesis is less severe; however, even in the portions where the halokinesis have been intense, it is possible to identify onlap patterns (fig. 3). This interpretation is confirmed by the analysis of recent 3-D data in the area.

In the case of the work area, the integration of the analysed data indicates that extrusive events are more important than intrusive ones. This conclusion is based on seismostratigraphic analysis and supported by the conspicuous presence of hyaloclastites and vesicular basalts in the cuttings and cores from the wells that have sampled the volcano-sedimentary sequence in the Cabo Frio Area.

Conclusions

The analysis of seismic reflections, in the work area, pointed to a set of diagnostic features that can lead to the identification of magmatic events and the distinction of intrusive from extrusive rocks, as well as their intercalations with epiclastic sedimentary sequences. The occurrence of extrusive events is very often associated with the presence of volcanic cones in seismic sections.

The sedimentary sequences that overlap this volcano-sedimentary section are not directly related to the magmatic pulses in the area; however, the pulses affected the palaeorelief of the seafloor, which controlled the turbiditic deposition.

The criteria proposed by this work may be used to identify and classify magmatic events in seismic sections in any context where they are associated with sedimentary sequences.

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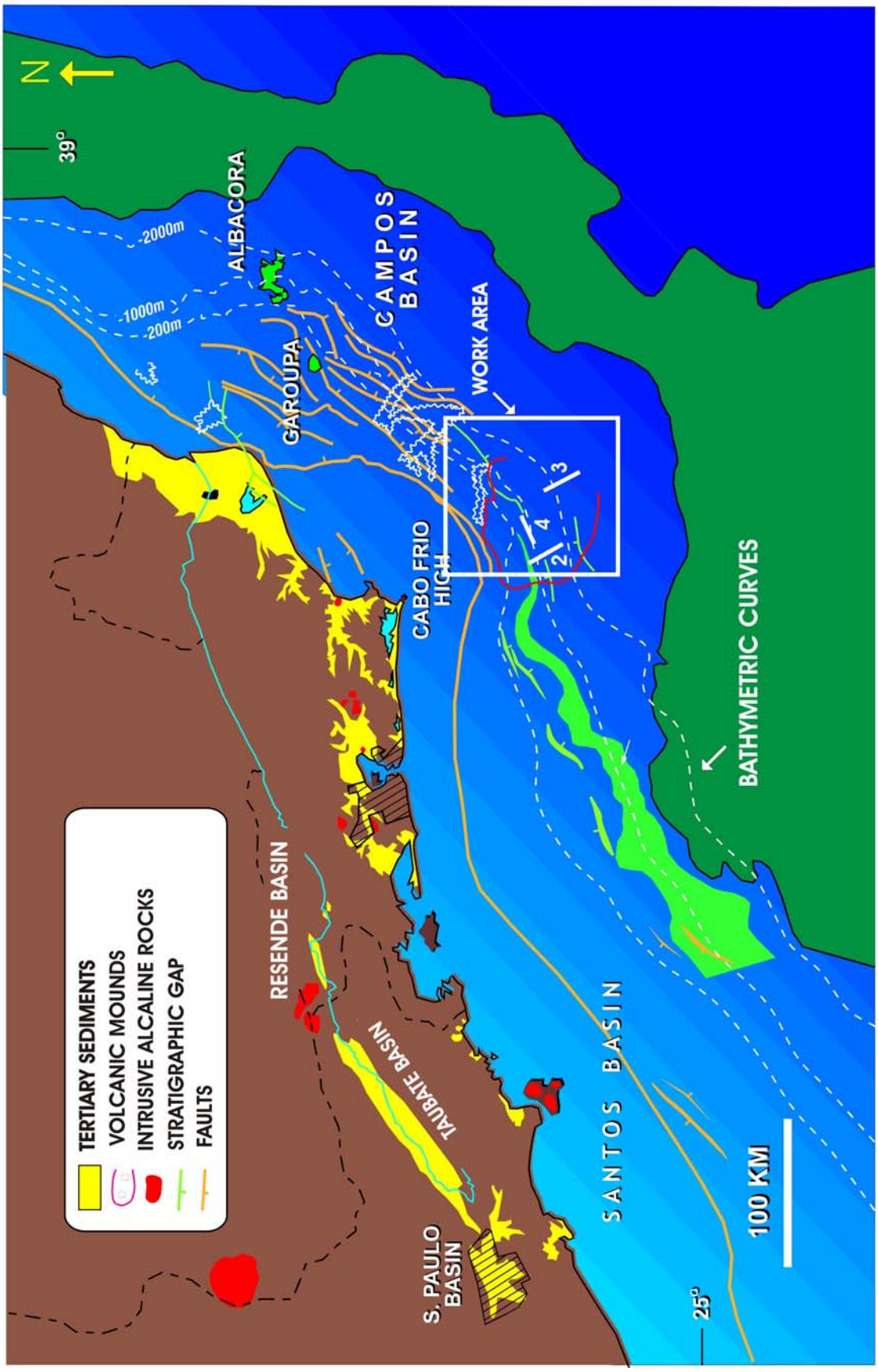

Figure 1 - Location map of Cabo Frio High and the Work Area, showing the locations of seismic lines corresponding to the figures 2, 3 and 4 (adapted from Mohriak et al., 1995).

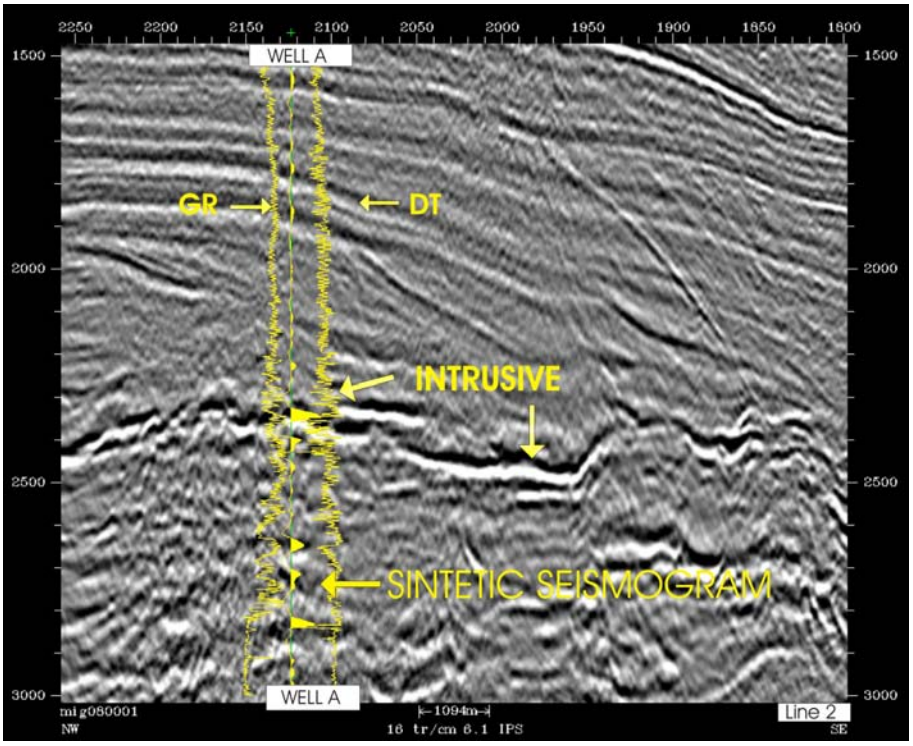

Figure 2 – TWT seismic line showing the seismic signature of intrusive rocks (adapted from Oreiro, 2002). See fig. 1 for location.

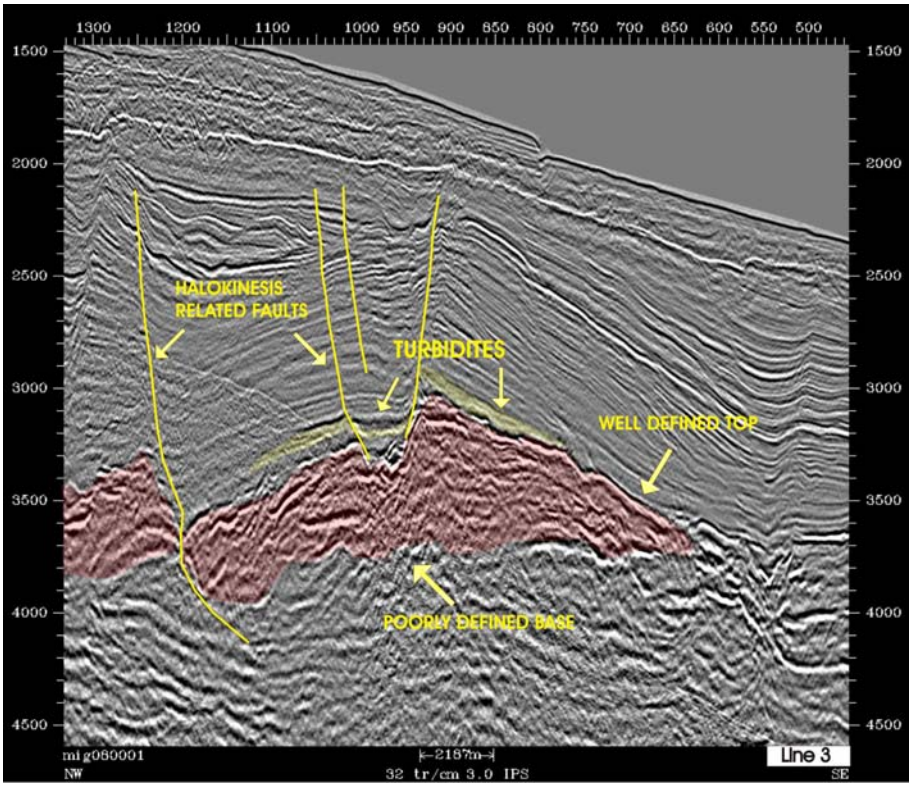

Figure 3 – TWT seismic line showing the volcano-sedimentary section (in red) and the overlapping turbidites (in yellow). Adapted from Oreiro (2002). See fig. 1 for location.

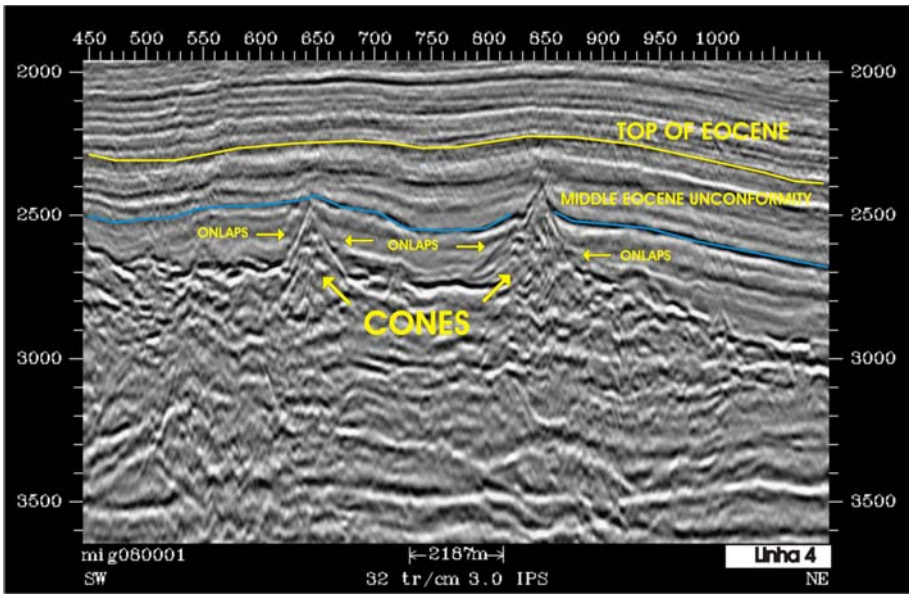

Figure 4 – TWT seismic line showing that the Middle and Upper Eocene epiclastic sequences onlap the volcano-sedimentary section (adapted from Oreiro, 2002). See fig. 1 for location.