# THE VAR TURBIDITIC SYSTEM: SEDIMENT SUPPLIES, SLOPE INSTABILITIES AND MASS WASTING

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## Abstract

The Var turbidite system is a small sandy system located on the Ligurian margin and basin. Still active during the present sea-level highstand, the system has been fed through time by the Var and Paillon canyons. Three major processes allow the transport and distribution of particles from the shelf to the deep basin: (a) large-sized failure-induced turbidity currents, (b) small-sized turbidity currents, (c) and hyperpycnal currents triggered at the Var-river mouth during high-magnitude floods. The continental slope of the Baie des Anges is also affected by numerous surficial failures, such as the 1979 event initiated during the extension of Nice airport. Small-sized failures are abundant at relatively shallow water depth, in areas where sediment supply from the Var and Paillon rivers has been high through time. Larger-sized failures occur at greater water depth, probably triggered by seismic activity.

*Keywords: Ligurian Basin, Var system, turbidity current, 1979 event, failures*

### The Var turbidite system: geological setting and morphology

The Var turbidite system is a small sandy system, extending seaward of Nice and the Var prodelta to the base of the continental slope nearby Corsica. The Var system has been built during the Pliocene-Quaternary in a flat-floored basin formed during the Messinian salinity crisis (1).

The Var system was fed through time by the Var and Paillon canyons that connect directly to the Var- and Paillon-river mouth. Only the Var Canyon is thought to be still active nowadays. The two canyons deeply incise the slope and coalesce at about 1500 m water depth to form the Upper Valley. At 2000 m water depth, the Upper Valley abruptly passes into the east-trending Middle Valley which extends 50 km eastward till a water depth of 2500 m where it reaches a continuous trend of salt diapirs and then bends to the southeast. The Lower Valley extends 100 km southwestward, feeding a sandy distal lobe at a water depth of 2700 m water depth. Along the whole system, gradient slope decreases from 11% in the canyon to 0.3% in the Lower Valley. The main morphological feature of the system is the well-developed right-hand levee called the Var Sedimentary Ridge (1, 2). Ridge height above the channel floor decreases from 400 m in the west to less than 30 m to the east. The morphology of the system suggests that significant deposition has been produced by both sandy and muddy turbidity currents (3). Evidence of recent erosive currents has been observed on deep-tow side-scan sonar images collected in the distal part of the Ridge (4).

### Processes of sediment supply

During the present highstand three major sediment transfert processes are active in the Var system:

- Large failure-induced turbidity currents, such as the "1979 event" when part of the Nice airport collapsed. Failures are generally induced by the conjunction of earthquakes and of an under-consolidated state of slope-sediment, although the "1979 event", had anthropic causes. The resulting current is a short-duration (a few hours), catastrophic and fast surge. On the canyon steep slopes inferred velocities are estimated at 30 m/s and are still in the order of 6 m/s 150 km away from the canyon head (4). As a consequence, cobbles and boulders can be transported near the bed over hundred of kilometres. Fine to medium sand are transported up to the distal lobe, more than 200 km from the continent.

- Small-sized turbidity currents; those are generated by retrogressive shallow failures on the slope or reconcentration process of particles near the shelf break during storms. Several day-long currents are common, as recorded by Gennesseaux *et al.* (5) in the Var canyon. These low-velocity currents are able to transport and deposit fine-grained particles on the slope and on the Var Ridge.

- Hyperpycnal turbidity currents ; triggered at the Var-river mouth during high-magnitude floods, when critical discharge is close to 1250 $m^3/s$ and sediment concentration about 42 $kg/m^3$. The Var river discharge curve is typically bimodal and flash floods can occur both in spring and autumn, owing to snow melt and convective rainfalls. Using the rating curve of the Var river, return period of floods triggering hyperpycnal flow is about 4 years (using instantaneous discharge values) and 21 years (using daily discharge values). Such currents transport significant amount of both fine-grained and coarse-grained particles. Typical hyperpycnite-deposits are found in the distal part of the Var Ridge where they exhibit thickness of about 5 to 20 cm.

The detailled analysis of one core collected on a terrace near the base of the Upper Valley indicates that during the last 100 years, 70% of the deposits result from hyperpycnal-flow activity, 5% result from failure-induced turbidity currents and 25% are the hemipelagic background. During the Holocene-Pleistocene time, failure-induced turbidity currents were as common as hyperpycnal flows (4).

### Slope failures

On october 16 1979, a large failure, involving at least 8 x $10^6$ $m^3$ of material, occurred at shallow water depth during infilling operations related to the enlargement of Nice airport. *In situ* observations and modelling results have indicated that the slide transformed into a debris flow then in a surge that reached the Var Ridge and probably the distal lobe. The surge broke two submarine cables located at about 80 km and 107 km from the failure area. On the upper slope, the failure generated a tsunami 2 m in height that caused damage and people death in the Antibes region.

Recent high-resolution multibeam survey of the Nice upper slope allowed detailed observation of the 1979 event and also revealed the degree of destabilisation of the area. Failures are more abundant near the Var- and Paillon-river mouth (about thirties of events) than in the central slope domain (about tens of events), but they are globally smaller (about one $km^3$ against several $km^3$ in the central zone). The 1979 failure appears as a medium-size slide. Failures are generated at shallow water depth, near the shelf break, in areas close to the Var- and Paillon-river mouth, and at greater water depth in the slope central zone. Failures are easily triggered in areas where sediment supply is important through time. This results in thick under-consolidated accumulations, deposited near steep slope, that can be destabilised under the action of gravity, or during episodes of flash floods reworking deposits at river mouth. In the central zone, where sediment supply is lower, external mechanismes such as horizontal or vertical acceleration during an earthquake seem to be necessary to trigger failures. In that case, volume of remobilised sliding sediment is more important.

### References

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