Preliminary Findings on Basin Architecture, Segmentation and Inversion on a Passive Margin Offshore Newfoundland

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ABSTRACT
Interpretation of new seismic, gravity and magnetic data over the Grand Banks and Orphan Basin suggest a more complex evolution of Mesozoic basins offshore Newfoundland than previously published. A case is made for Late Triassic/ Early Jurassic transfer zones (TZ) that segment basins offshore Newfoundland with subsequent multiple reactivation, mainly in the Late Jurassic/Early Cretaceous and Mid Cretaceous times. The initial rift basin architecture extends northward beyond the Jeanne d'Arc Basin into the Orphan Basin across a major transfer zone. *Researchers generally accept that transfer zones in rift basins are parallel or nearly parallel with the principal direction of horizontal extension as are transform faults in oceanic crust. (Meisling, 2001)*

Previous work (Enachescu, 1987) has documented three phases of rifting coupled with subsidence to provide the framework for structural and stratigraphic controls for the Jeanne d'Arc and other basins offshore Newfoundland. The three rift phases have been attributed to NW-SE extension in the late Triassic/ Early Jurassic, E-W extension in the Late Jurassic/ Early Cretaceous and Mid-Cretaceous NE-SW extension.

New interpretation suggests that during initial rifting two major transfer zones segmented the developing rift basins north of the Newfoundland fracture zone. The NW trending Avalon transfer zone separated the Whale, Horseshoe and Carson/Bonnition Basins from the Jeanne d'Arc Basin. The NW trending Cumberland transfer zone separated the main Jeanne d'Arc Basin from the Late Triassic/Early Jurassic rift basin underlying the Orphan Basin (*Fig. 1*). The two major transfer zones extend eastward into transfer faults along which lie seamounts, the Avalon TZ aligns with the Newfoundland Seamounts and the Cumberland TZ with the Milne Seamounts. The seamounts represent an area of weakened crust. During initial rifting stresses are transferred obliquely across the transfer zones (*Fig. 1*), which do not physically displace the basins along the transfer fault zone. Within the segmented basins minor transfer faults developed with somewhat regular spacing to further segment and compartmentalize the basins. The initial Late Triassic/Early Jurassic rift basin architecture is outlined in *Fig. 1* illustrating that development of the Orphan Basin was contemporaneous with basins south of the Cumberland TZ.

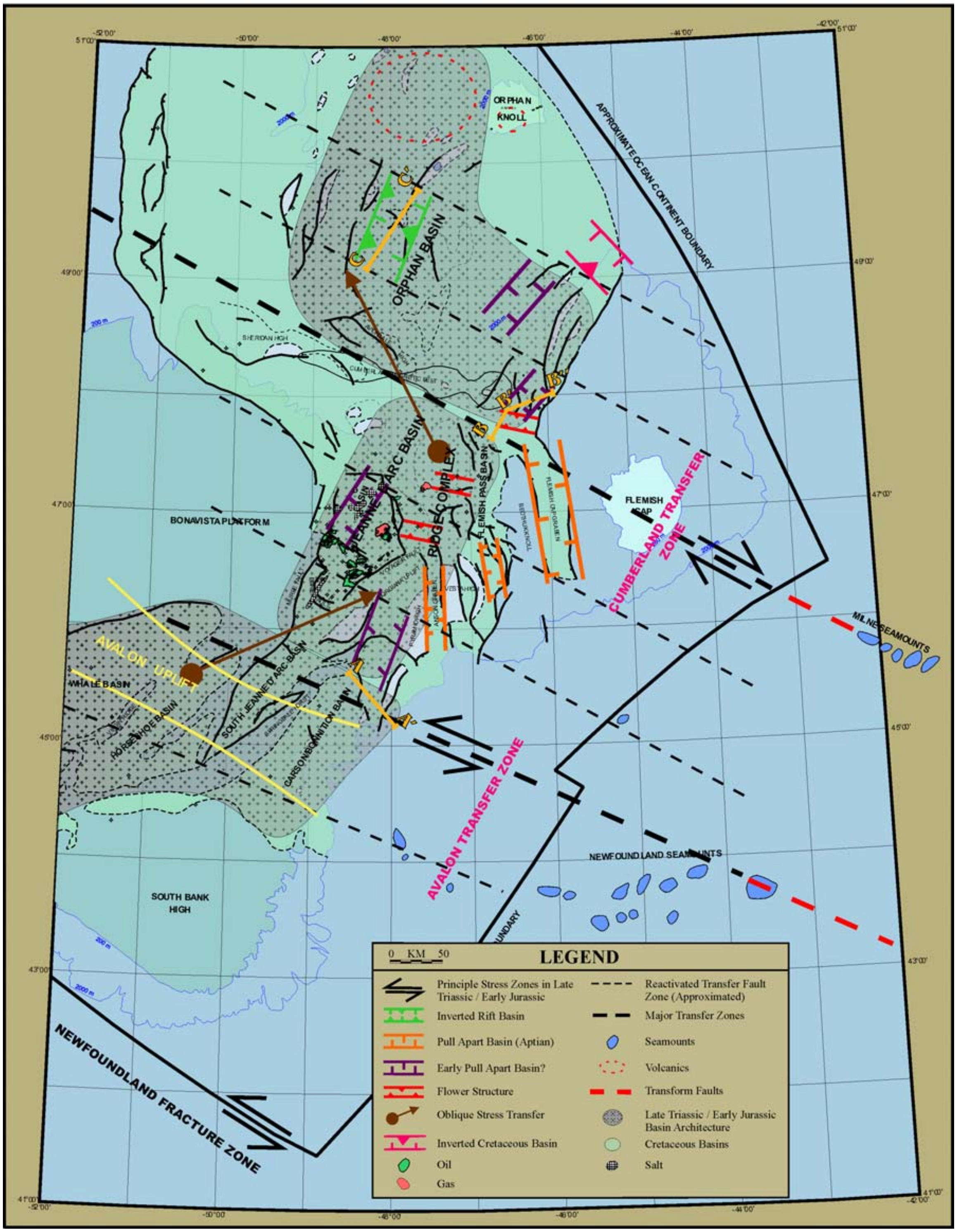

Fig. 1: Rift basin architecture and mappable strike-slip features offshore Newfoundland.

The Late Triassic/Early Jurassic transfer zones aligned roughly in a NW direction to form fabrics and structures which were reactivated from Jurassic through to Teritary, with the two main phases in the Tithonian/Berriasian and Aptian/Albian times. New seismic data across the Avalon TZ (*Fig. 2*) show an arch within the zone. The data show thinning and onlap of reflectors onto both sides of the arch in the Late Jurassic/Early Cretaceous. Thickening away from the arch suggests uplift at this time due to reactivation of transfer faults within the Avalon TZ. Folding of the strata east of the arch and erosion over its crest in the Mid Cretaceous suggests another significant reactivation of transfer faults within the Avalon TZ. Notable on Figure 1 is the alignment of the Avalon uplift with Avalon transfer zone. The Avalon uplift occurred in the Late Jurassic shedding the Jeanne d' Arc Formation sands from south to north axially into the Jeanne d'Arc Basin synchronous with the first significant major reactivation of transfer zones.

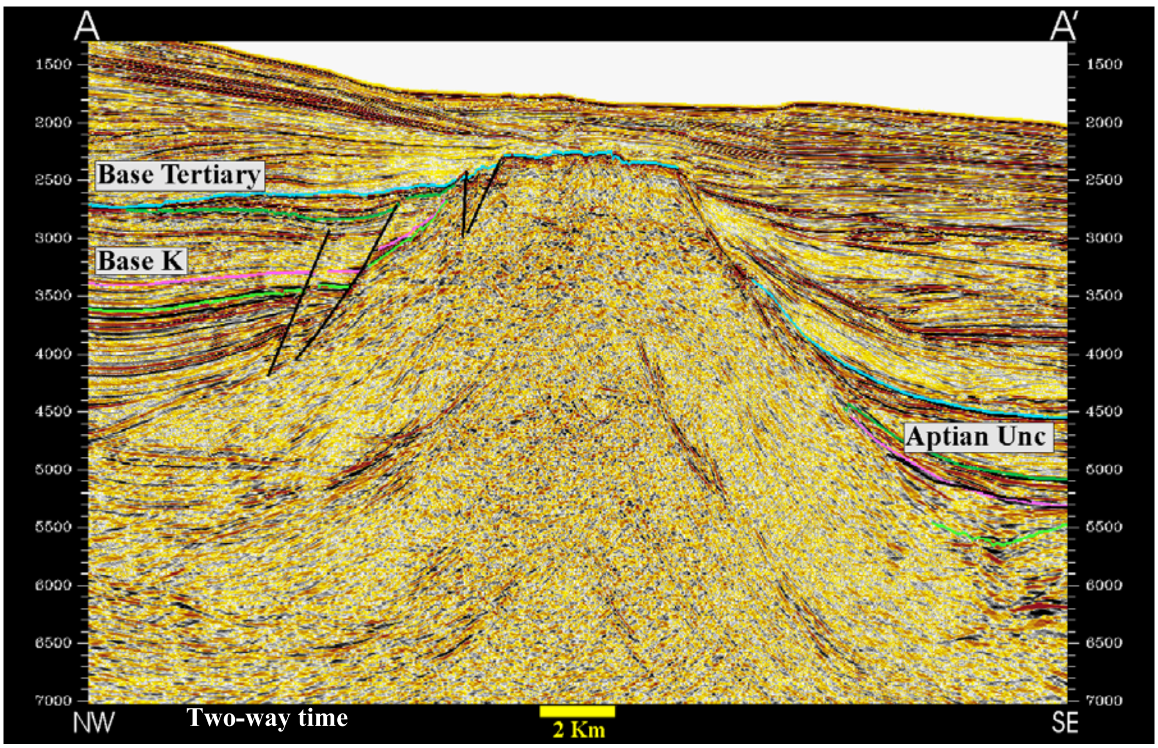

Fig. 2: Basement arch. Folding began in the Jurassic and continued into Tertiary. Seismic data compliments of TGS Nopec.

Seismic lines across the Cumberland TZ show a major NW trending transfer fault within the zone. The seismic line B-B′-B″ in *Fig. 3* crosses the Baccalieu subbasin which is interpreted as a Late Triassic/Early Jurassic pull apart basin. On section B′-B″ there is an evident thickening of the lower and upper Jurassic section toward the west, which is later uplifted and Late Jurassic sediments eroded. Onlap of Early Cretaceous sediments on the uplifted Jurassic high

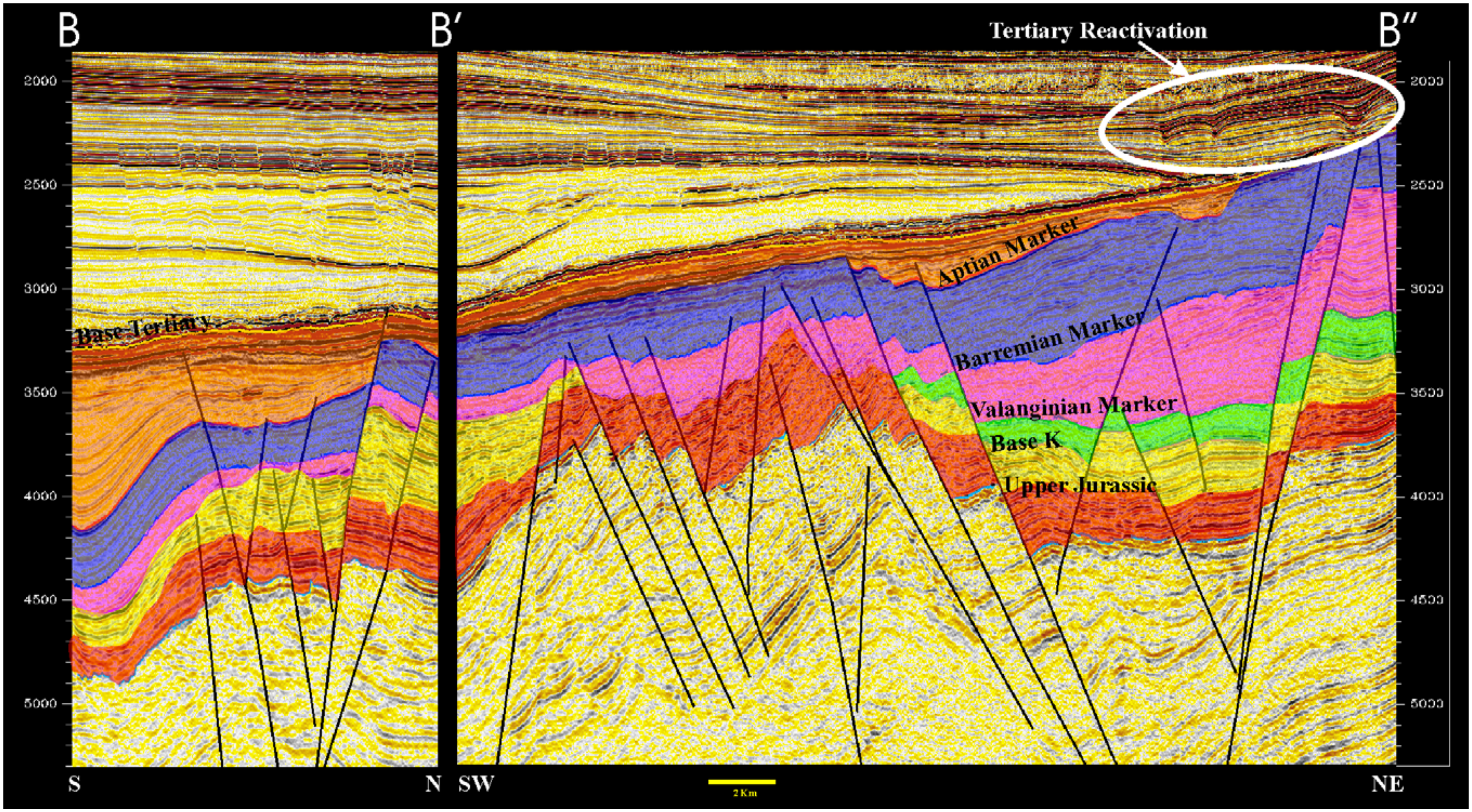

Fig. 3: Line B-B' transects a negative flower structure that trends W-NW. Line B'-B" shows erosion of Upper Jurassic sediments and onlap of Cretaceous sediments from the NE on the high. Seismic data compliments of Petro-Canada.

westward and thickening eastward suggest a Late Jurassic/Early Cretaceous inversion of the basin. This inversion is due to reactivation of the NW trending transfer fault in the Late Jurassic/ Early Cretaceous. Mid Cretaceous "extension" reactivates the NW trending transfer fault and again the Baccalieu sub-basin is inverted creating the current Baccalieu structure. High angle and reverse faults are mapped in several structures within the basin and section B-B′ shows a negative flower structure that trends in a WNW direction. Channel like features in the Tertiary are shown in the section and are interpreted as strike slip faults due to reactivation of the transfer zone in the Tertiary.

Significant evidence for reactivation and inversion of transfer zones are outlined in Figure 1 and represent only a portion of those mappable features. Figure 4 lies within the Orphan Basin along strike of an inverted rift basin. The Cretaceous aged sediments are folded and are pushed up over regional basement in the northeast. Multiple flower structures have been mapped along the identified transfer zones in all basins. The highly structured Ridge Complex has gently folded Tertiary sediments overlying thin Cretaceous on Jurassic sediments and is transected by transfer faults in a NW direction. At least two transfer faults transect the ridge in a NW direction. This coupled with the lack of Cretaceous sediment and interpreted flower structures implies multiple strike slip movement from Late Jurassic to Tertiary. Several Aptian/Albian pull apart basins are mapped in the Flemish Pass area with Pre-Aptian pull aparts being mapped in other basins.

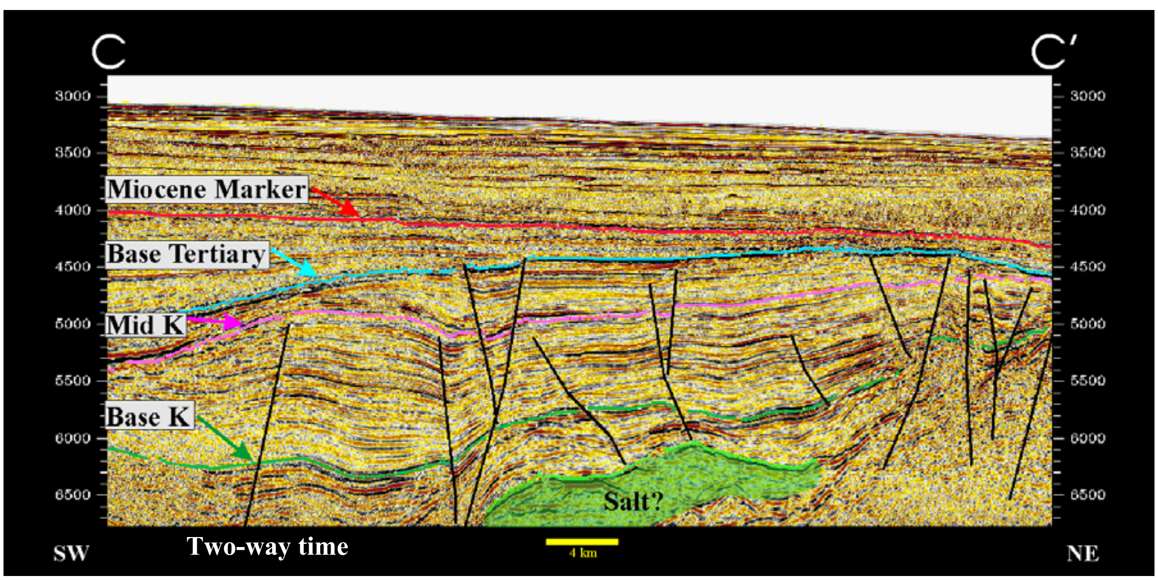

Fig. 4: Inverted rift basin. The Cretaceous sediments are pushed up over regional basement. Seismic data compliments of GSI.

The implications of this new interpretation are that the "passive margin" offshore Newfoundland formed as an obliquely rifted margin with three significant episodes of transfer fault activation during the Late Triassic/ Early Jurassic, Late

Jurassic/ Early Cretaceous and Mid Cretaceous times. Minor strike-slip movement continued well into Tertiary. This interpretation suggests the “extensional” directions are currently poorly defined. The transfer zones controlled the initial basin architecture and sedimentation with subsequent reactivation of the transfer zones controlling sedimentation, structural traps and hydrocarbon migration. This interpretation offers a new insight on exploration risk assessment for the area, identification of exploration plays and how current fields are produced offshore Newfoundland.

References and related materials.

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