Seismic Studies of the Jeanne d'Arc Basin

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Foreword

This file contains reproductions of the text and figures displayed in the form of a poster at Forum '89, Geological Survey of Canada, Oil and Gas Activities in Canada. The meeting was held at the Calgary Convention Centre, February 27-28, 1989.

INTRODUCTION

The Jeanne d'Arc basin, located beneath the Grand Banks of Newfoundland (Fig. 1), has been the site of intensive seismic exploration since the discovery of the Hibernia oil field in 1979. This study focuses on the western basin margin and provides an alternative interpretation of fault type and geometry to that currently in vogue.

THE BASIN MARGIN PROBLEM

Sloping reflections in the region of the Hibernia oil field have been interpreted as the shallowest part of a major basement-involved fault, with listric geometry dipping to the east, or alternatively the sole of a Paleozoic mega-thrust which has subsequently been offloaded to provide the space required to preserve the substantial volumes of Mesozoic sediment within the basin. The interpretation proposed here is that the western margin of the basin consists of a zone of offset and overlapping normal faults (Fig. 2), downthrown to the east, with variable throw along strike. The faults are planar-normal and of high angle-nature rather than low-angle and listric (Figs. 3 and 5).

In the Hibernia and Flying Foam areas (Figs. 6, 7, 8 and 9) sloping reflections are interpreted as the expression of tilted basement fault blocks and sloping basin margins. The rate of dip on the Western hinge zone compares favorably with the slopes associated with the basement tilting on the east of figure 5, and the southerly tilt of the terraces displayed in figure 4. Additional geological evidence for the nature of the margin is provided by the Hibernia I-46 well (Fig. 10). Near the bottom of the well a thick, high velocity carbonate of early Jurassic age was encountered. Below the carbonate a drilling break occurred and an increase in sodium chloride in the mud returns noted. This is interpreted to represent early Jurassic and Triassic salts deposited over the basin margin, preserved during collapse of the basin and later unconformably overlain by younger Jurassic and Cretaceous strata.

In addition to the evidence presented above the position of the axis of deposition in the basin as seen in figure 2 shows a shift northward from an axis along the fault to one in the centre of the Jeanne d'Arc basin. This suggest strongly that simple half graben tectonics cannot be the mechanism for full basin growth, if this was the mechanism then the axis of deposition should remain static in the case of a simple half graben or migrate older beds eastward with time in the case of a low-angle fault. The change in angle of fault plane dip from south to north as displayed in the seismic sections here would require unrealistic rotation of the fault plane to achieve the geometry of a listric fault in the north.

The low angle of dip associated with the previously proposed listric boundary fault in the Hibernia area is not typical of the margin. The fault geometry proposed here provides an explanation for apparent offsets along the basin margin, these have been interpreted elsewhere as indicative of the presence of transfer faults.

CONCLUSIONS

A more complex geometry and history of margin development is proposed than has been described by others. The current interpretation is considered to be more consistent with observed fault patterns and geometries in active rift basins. The constraints on models of basin formation for interior rift basins with the proposed geometry are significant.

FIGURE 1

Location map showing the major Mesozoic sedimentary basins of the Grand Banks of Newfoundland. The area outlined in red represents the area mapped in figure 2 and the lines the location of displayed seismic data.

FIGURE 2

Time structure map of Pre-Mesozoic basement along the western edge of the Jeanne d'Arc basin. Note the depositional axis shift away from the hinge zone from south to north and the prominent basement ridge separating the Hibernia area from the Mercury subbasin.

FIGURE 3

Seismic line 83-4944 illustrates the very steep nature of the Murre fault at this location in the basin. Also note the fact that the thick salt units in this part of the basin insulate shallow faulting from the basement; and the prominent volcanic horizon present within the salt is clearly identified on this line.

FIGURE 4

Seismic line 83-2556 displays the southward dip of interpreted fault terraces in the Hibernia region. Jurassic beds are interpreted to cover much of the basement surface and show sever stratigraphic onlap of late Jurassic and early Cretaceous units. Also note the deep sub-parallel reflections to the basement surface at 6 seconds.

FIGURE 5

Seismic line 83-4992 displaying the steep nature of the basin bounding Murre fault. In addition note the syn-sedimentary listric nature of the Egret fault and its association with salt migration. The details of stratigraphy seen on this and other seismic sections displayed should be viewed in association with "Mesozoic Stratigraphy of the Jeanne d'Arc Basin", authors K.D. McAlpine and A. Edwards.

FIGURE 6

Seismic line 83-5048 illustrates a sloping reflector terminating 1.5 to 2 seconds beneath the shallow upper termination of the fault in the Tertiary. Earlier growth on the fault is evidenced by the over-thickening of the Ben Nevis and Avalon Formations.

FIGURE 7

Seismic line 83-5056 shows the steep dip of the basin margin terraces, steep termination of the Murre fault and rotation of the sediments onto the surface.

FIGURE 8

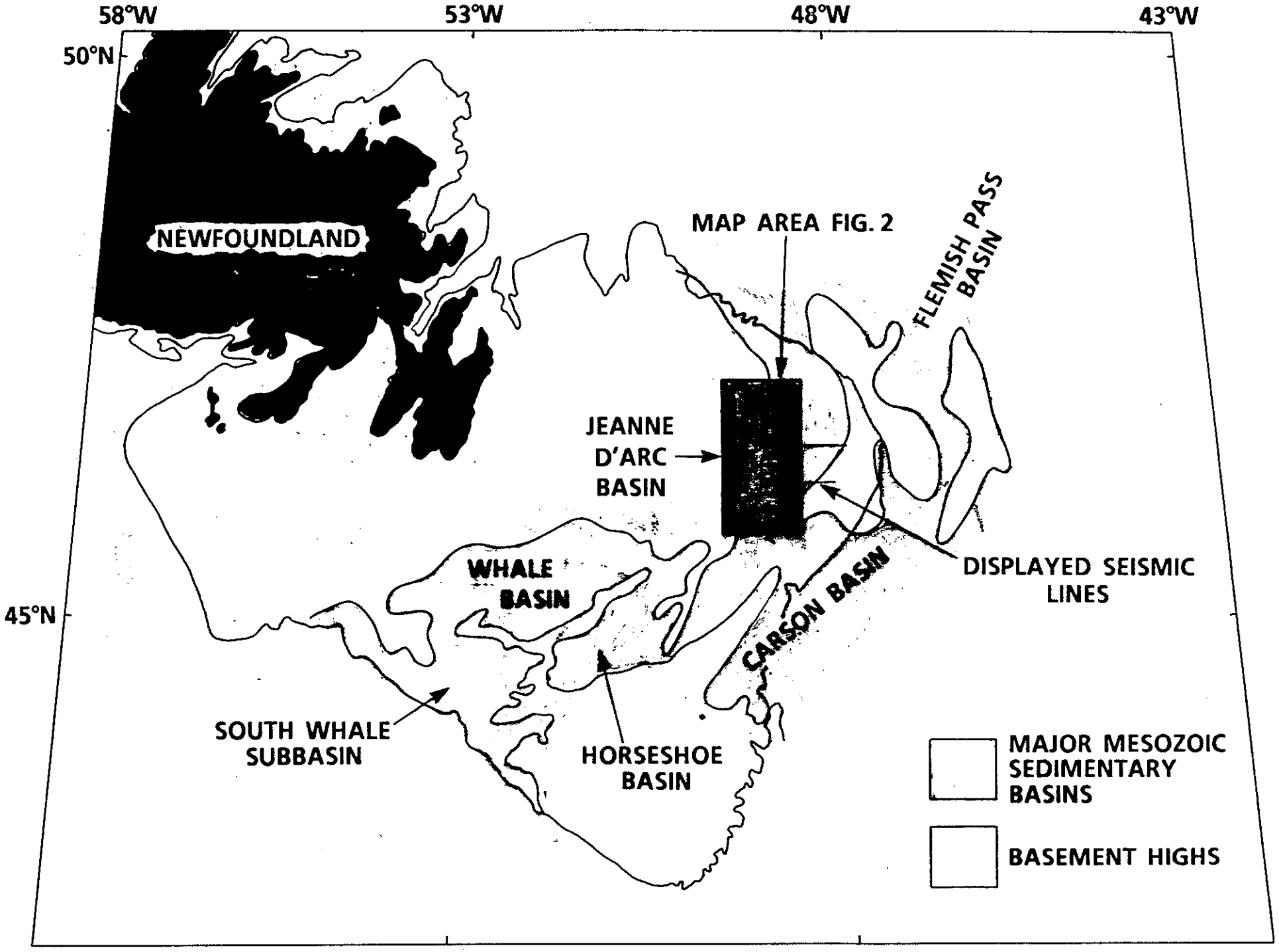
Seismic line 83-5076 illustrates the steep dip of the basement in this region, note the termination of the steep event some 500 m below the position of the shallow cutting Murre fault, the steep onlap of Cretaceous and younger beds and the massive throw associated with the syn-sedimentary Nautilus fault.

FIGURE 9

Seismic line CNF82-9 cuts through the Mercury fault at its northern end and crosses the major anticline of Flying Foam. Note the termination of strongly dipping basement event 1 second below the shallow cut of the fault into Tertiary section. Also note the late early Cretaceous growth of sedimentary wedges behind the growing Flying Foam anticline. This suggests possible development of a décollement surface along which sediments have slid laterally into the basin, possibly lubricated by salt(see figure 10).

FIGURE 10

Seismic line 83-5068 shows the projected location of the Hibernia I-46 well with a velocity log superimposed to show the level of the early Jurassic carbonate with dip parallel to interpreted basement, and the zone in which a drilling break and increased sodium chloride in the mud returns occurred.



LOCATION MAP

Fig. 1