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Gaspé belt subsurface geometry in the northern Québec Appalachians as revealed by an integrated geophysical and geological study: 1 — Potential field mapping

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ABSTRACT

Together, recent gravity and high-resolution aeromagnetic datasets are used to qualitatively investigate the upper- and middle-crustal geometry of the Middle Paleozoic Gaspé belt in the northern Appalachians. Long-wavelength potential field anomalies define two sub-basins that are divided by northeast trending gravity highs. For each sub-basins, gravity lows correlate with the youngest rock units.

Maps that highlight anomalies associated with near surface features, at the expense of those related to deeper sources, provide an important supplement to the spatially discrete observations derived from bedrock mapping. Analysis of such maps indicates that the sub-basins are characterized by different structural patterns and that faults trending obliquely compared to the main structural grain have been previously underestimated.

The geometry of the Gaspé belt as revealed by this integrated geophysical and geological study bears similarities with orogens exhibiting lateral extrusion. This geometry is interpreted as the result of a heterogeneous strain regime in front of an indenter corresponding to the Early Paleozoic Gander/Dunnage crustal block. The indentation tectonic model is supported by: 1) the various strike and kinematic of faults that suggest a strongly heterogeneous strain regime; 2) the greater geological complexity and the occurrence of faults with a significant thrust component in front of the indenter; 3) the predominance of dextral strike-slip faults in the eastern Gaspé Peninsula that result in lateral material transport away from the indenter; 4) the location of abundant Devonian magmatic dykes, sills and stocks in a fault-bounded zone that experienced local extension; 5) the occurrence of block rotation.

1. Introduction

Potential field data (gravity and magnetic) represent spatially continuous grids of information that may help to develop a regional framework within which more detailed geological studies may be integrated. The analysis of long wavelength anomalies, that are usually (but not always) associated with relatively deep sources, enables the distinction of regional lithotectonic domains that may be characterized by different sedimentary infill thickness and/or different basements. Conversely, potential field maps that enhance short-wavelength anomalies are a useful complement to surface geological data in little studied areas or in zones of poor bedrock exposure. The map analysis of recent gravity and aeromagnetic surveys in the northern Québec Appalachians is the main objective of this paper. Forward quantitative modeling of the same datasets will be the aim of a companion paper.

Despite the fact that several Middle Ordovician to Permian orogenic pulses have modelled the Appalachians orogen, lithotectonic zone boundaries exhibit an overall parallelism each other and with the present-day boundary of Grenvillian basement rocks. This map pattern makes the Appalachian orogen geometry, one of the simplest around the world. Since three decades (Thomas, 1977), the smooth flexures of lithotectonic zones has been interpreted as the consequence of a reentrant-promontory geometry of the Laurentian margin inherited from a transform-rift configuration during the early (Late Proterozoic to Cambrian) stages of rifting. Potential field data provide the opportunity to challenge the overall parallelism of the Appalachians tectonostratigraphic zones. Our results indicate that structures trending obliquely compared to the main structural grain have been underestimated because of poor bedrock exposures and of a tendency of geologists to correlate geological features over long-distance when little data is available.

2. Geological framework

In mainland Canada (Fig. 1), sedimentary and volcanic rocks belonging to the Gaspé belt span the time range between the Middle to Late Ordovician Taconian and the mainly Devonian Acadian deformation events or orogenies. Middle Paleozoic rocks forming

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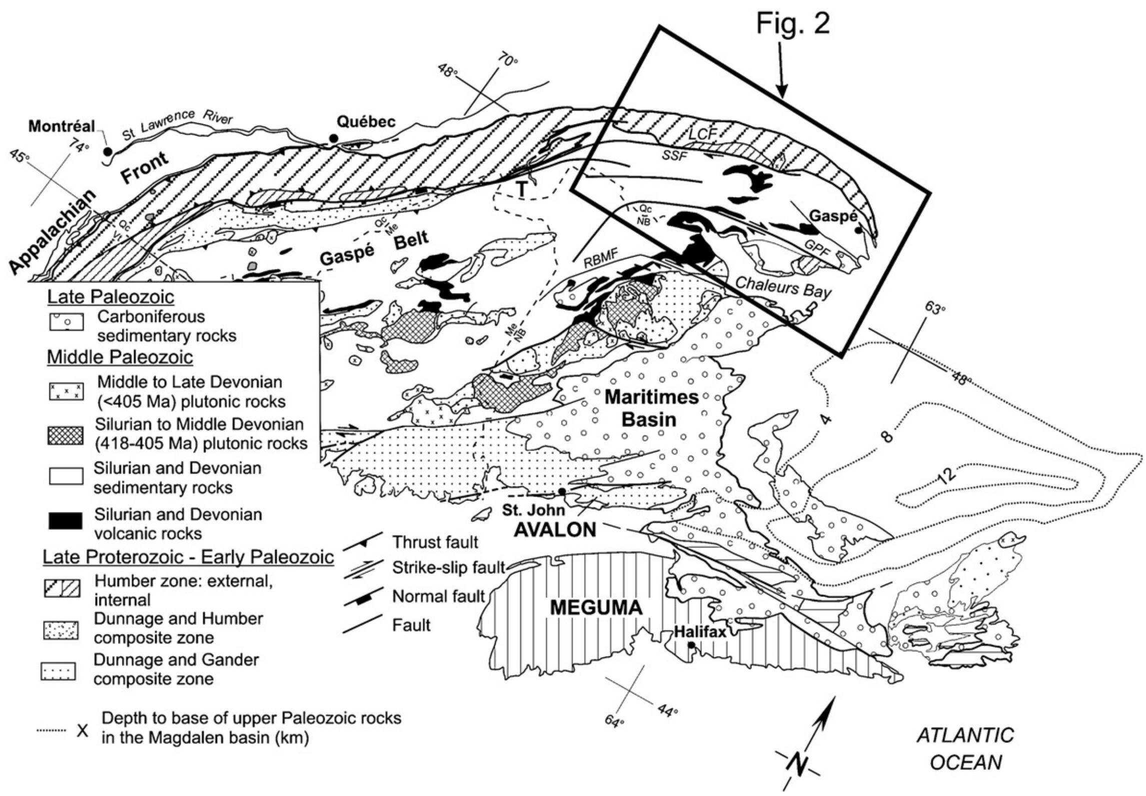

Fig. 1. Simplified geological map of the northern Appalachians. Modified from Tremblay and Pinet (2005). T, Temiscouata area; Province boundaries: Me, Maine; NB, New Brunswick; Qc, Québec; Vt, Vermont. Others abbreviations are listed in Table 1.

the Gaspé belt unconformably overly or are in fault contact with Early Paleozoic rocks belonging to Laurentia (Humber zone), to oceanic domain(s) (Dunnage zone) and to peri-Gondwanian affinity rocks (Gander zone). The relationship between the Early and Middle Paleozoic rock assemblages is well documented on the northern and southern boundaries of the Gaspé belt (Bourque et al., 2001; Wilson et al., 2004) but remains poorly documented in the central part of the belt, where older domains are buried under the Middle Paleozoic sedimentary cover.

In the northern part of the Gaspé Peninsula, Late Proterozoic to Late Ordovician rocks of the Humber zone (Williams, 1979, Williams, 1995) form the basement of the Gaspé belt. The contact between the Humber zone and the Gaspé belt corresponds either to a fault (Shickshock-Sud fault, SSF) or to a regional unconformity (Fig. 2). Most of the deformation in the Humber zone is generally attributed to the Ordovician Taconian orogeny (St-Julien and Hubert, 1975; Slivitzky et al., 1991). The Humber zone is divided into external and internal subzones by the Lac-Cascapédia Fault, which separates rocks with contrasting styles of deformation and metamorphism (St-Julien and Hubert, 1975, Fig. 1). The external Humber includes Cambrian to Middle Ordovician slope and rise sedimentary rocks deposited along the Laurentian continental margin during the rift and drift periods (see Lavoie et al., 2003, for a review) and Middle to Late Ordovician syn-orogenic flysh deposits associated with the building of the Taconian orogenic wedge (Hiscott, 1995). The internal Humber zone is composed entirely of rocks of the Late Proterozoic to Early Cambrian Shickshock Group, which are dominantly tholeiitic metabasalts with minor metasedimentary rocks (Camiré et al., 1995).

Early Paleozoic rocks attributed to the Dunnage zone represent remnants of oceanic and island-arc domains (Williams, 1979, van Staal et al., 1998). In the northern Gaspé Peninsula, the Mont-Albert ophiolitic complex structurally overlies the Humber zone (Figs. 2B and 3). Radiochronologic data (Pincivy et al., 2003) date the ophiolite accretion as well as the metamorphism of underlying rocks to the Late Ordovician (454–459 Ma). In the Chaleurs Bay area (Fig. 2), Dunnage zone rocks that form the basement of the Gaspé belt correspond to Early Paleozoic ophiolitic remnants (Fournier Group, van Staal et al., 1990; Fig. 2B) and picritic to andesitic flows formed in an island-arc setting (Balmoral Group; Wilson, 2003, Wilson et al., 2004; Fig. 2B). In northern New Brunswick, a narrow belt of Late Ordovician–Early Silurian blueschist marks the contact between ophiolitic rocks and Early Paleozoic rocks belonging to the Gander zone (van Staal et al., 1990 and 2003, Fig. 3).

Table 1
List of abbreviations used in the text and figures

Abbreviations used in the text and figures
BNOF, Bras-Nord-Ouest Fault
CF, Causapscal Fault
GA, Gastonguay anticline
GCF, Grande Cascapédia fault
GPF, Grand Pabos Fault
GRF, Grande-Rivière Fault
LCF, Lac-Cascapédia Fault
LMS, Lac-Matapédia Syncline
MAS, Mont-Alexandre Syncline
MBS, Monts Berry syncline
MSF, Marcil-Sud Fault
MSJF, Mont Saint-Joseph Fault
RBMF, Rocky Brook-Millstream Fault
RF, Restigouche Fault
RGF, Rivière Garin Fault
RMF, Rivière Madeleine Fault
RMCSC, Rivière Madeleine–Campbellton structural corridor
RS, Ristigouche Syncline
RSJF, Rivière Saint-Jean Fault
SF, Sellarsville Fault
SFF, Sainte-Florence Fault
SSF, Shickshock-Sud Fault
TLF, Troisième Lac Fault