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Applications of water-based magnetic gradiometry to assess the geometry and displacement for concealed faults in the southern Adirondack Mountains, New York, U.S.A

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ABSTRACT

An integrated magnetic gradiometry and structural analysis was conducted on three lakes in the southern Adirondacks Mountains, New York, in order to develop a geometric and kinematic model for concealed and long lived faults that transect the Proterozoic basement structures, offset Paleozoic strata to the south, and may be associated with the development of the post-Paleozoic cratonic dome (the Adirondack dome). Two lakes occur along the trace of two of the most prominent topographic lineaments that have been proposed to be faults in the southern Adirondack Mountains, and a third lake is located at the apparent fault intersection. Hinkley Lake occurs over the east–west trending lineament that corresponds to the trace of the Prospect fault. Indian Lake resides in a set of north–northeast trending pronounced lineaments that transect an anorthosite-cored structural dome and are inferred to be faults on the NYS geologic map. Piseco Lake is immediately adjacent to the intersection of the two proposed fault zones (Prospect and Indian Lake fault zones). Magnetic surveys were conducted on all three lakes, resulting in anomaly maps. Accompanying two dimensional geologic models for Hinkley and Piseco Lake were produced. At Piseco Lake, field evidence supports a brittle deformation history with sinistral-normal displacement. A similar deformation history is consistent with field data collected at Indian Lake. Correlation of the two dimensional magnetic models resulted in a sinistral, releasing-bend fault geometry beneath Piseco Lake, and the fault truncation of a granitic gneiss cored antiform for the subsurface geology of Hinkley Lake. The magnetic data and models suggest that Piseco Lake resides over a sinistral, pull-apart structure with sufficient throw to preserve the lowermost Paleozoic strata that once covered much of the Adirondack dome. This would account for both sinistral strike-slip and normal displacement on the interpreted faults, at Piseco and Indian Lakes, and rotation of structural blocks as the result of fault interaction. Relative timing, regional relationships, and ties to published ages suggest that the distribution of the faults is a relic of Neoproterozoic Iapetan rifting, Paleozoic displacement, and Mesozoic uplift of the Adirondack dome. Finally there is probable correlation of these faults with modern seismic activity.

1. Introduction

The Adirondack Mountains of northern New York, USA, are underlain by Mesoproterozoic crystalline rocks associated with the Grenville Province, and these ancient rocks formed through a complex and extended intrusive, deformational, and metamorphic history (i.e. Chiarenzelli and McLelland, 1991; Chiarenzelli et al., 2010; McLelland et al., 2001, 2010; Rivers, 2008). The Adirondack massif, the southeastern extension of the Grenville Province in New York (Fig. 1), is exposed in a crust-scale dome (the Adirondack dome) that is surrounded by Paleozoic sedimentary rocks, crosscut by presumed brittle faults (Isachsen, 1975, 1981; Isachsen and Mckendree, 1977; Isachsen et al., 1983), and developed by differential uplift 168–83 million years ago (Roden-Tice et al., 2000). Jacobi (2002) demonstrated that basement structure in some regions of New York State controlled the distribution and orientation of brittle faults in the overlying Paleozoic strata, and some of the faults had a substantial influence on patterns of Paleozoic sedimentation (Jacobi and Mitchell, 2002). Active seismic zones within and marginal to the Adirondack massif are interpreted to be active fault zones, such as the St. Lawrence fault zone that is coincident with the northeast-southwest trending St. Lawrence Seaway (Wallach, 2002).

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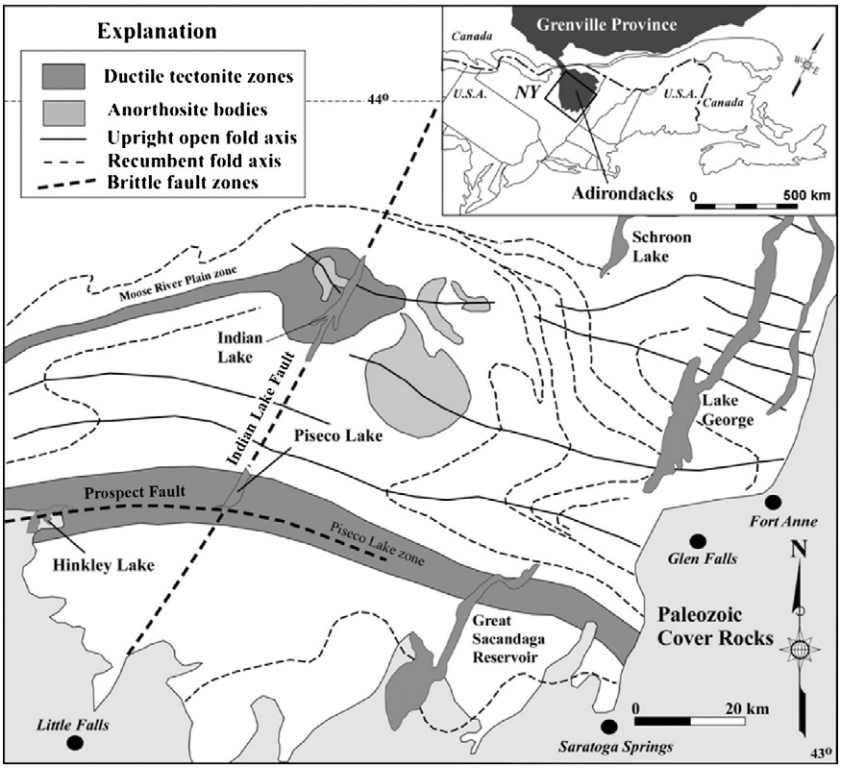

Fig. 1. Schematic geologic map for the southern Adirondack region, New York. The heavy dashed lines represent the faults of this investigation.

Numerous northeast trending, long, narrow valleys and elongate lakes dominate the landscape of the Adirondacks and define major topographic lineaments (Fig. 2). Many of these lineaments have been inferred to represent the location of northeast striking and steeply dipping faults and fracture zones (Daneshfar and Benn, 2002; Isachsen, 1975, 1981; Isachsen and McKendree, 1977; Isachsen et al., 1983). There are a few known locations within the Adirondack dome where northeast striking faults served as the borders for small graben that contains Paleozoic sedimentary rocks (Isachsen, 1975; Isachsen, 1981). The presence of graben led to the conclusions that the Paleozoic strata once covered the basement and that doming of the crust post-dated the graben strata.

Most of the inferred faults in the Adirondacks occur in some of the deepest valleys having relatively narrow (1–3 km), but elongate (15–30 km) lakes, such as Long Lake, Indian Lake, Schroon Lake, and

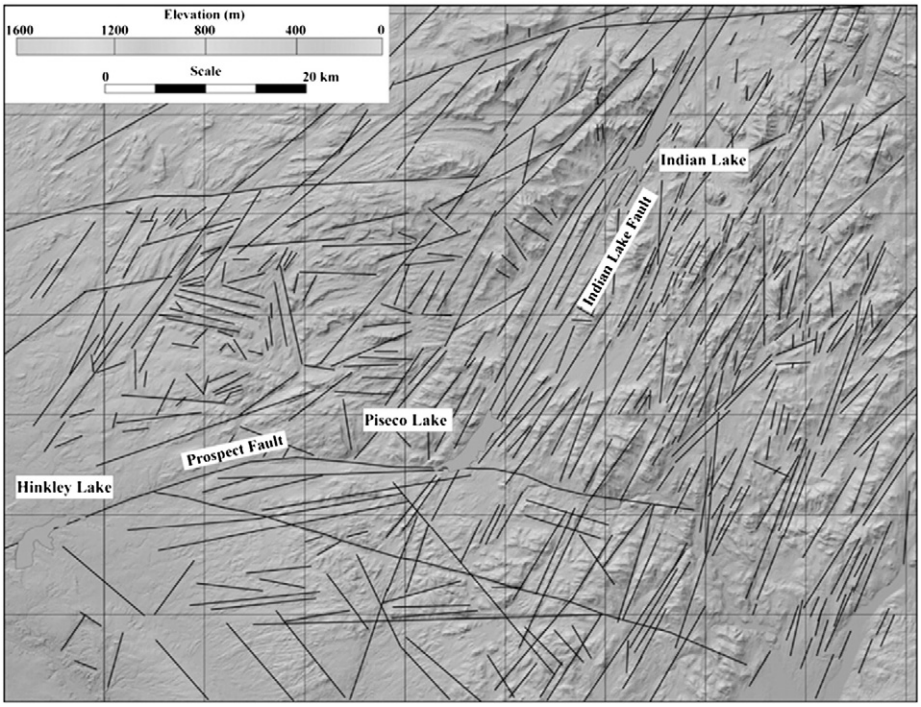

Fig. 2. Digital elevation model for the southern Adirondacks with interpreted lineaments. Note the locations of Indian, Piseco and Hinkley Lakes. The grid on the map is ten square kilometers.