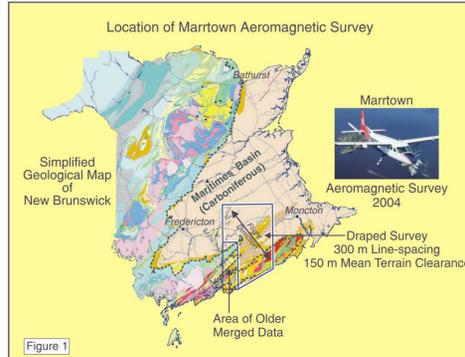
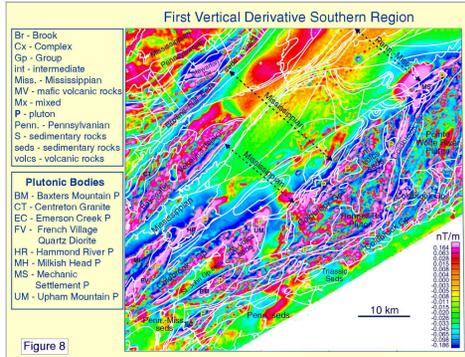


In March 2004 an airborne magnetic survey was completed in the central part of southern New Brunswick (Kiss, 2004) (Fig. 1). The survey was named the Marttown survey after the rural community located near the centre of the survey area, which lies approximately 10 km northwest of the town of Sussex. The area, bounded to the north by latitude 46° 15', and by latitude 45° 15' or the coast of the Bay of Fundy to the south. To the east it is bounded by longitude 65° 10', and to the west by longitude 66° and longitude 65° 45' north and south, respectively, of latitude 45° 45'. The area measures approximately 111 km in the north-south direction, and has a maximum east-west width of about 65 km. The survey was conducted along flight-lines oriented northwest-southeast crossing the prevailing geological strike approximately at right angles. Flight-line spacing was 300 m and the aircraft flew at a targeted mean terrain clearance (MTC) of 150 m above a draped flight-surface computed prior to the survey. Older non-draped aeromagnetic data collected using the same spacing and MTC between longitudes 66° and 65° 45' (Fig. 1) have been recompiled, regrided and merged with the data from the new survey.

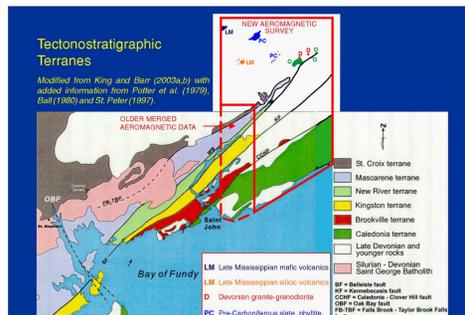
The northern and central parts of the area are underlain by mainly Upper Palaeozoic sedimentary rocks of the Maritimes Basin, whereas the southern coastal part of the area is dominated by Neoproterozoic and Lower Palaeozoic rocks. A preliminary geological interpretation of the combined data set was presented by Thomas and Kiss (2004). This open file provides documentation of that interpretation.



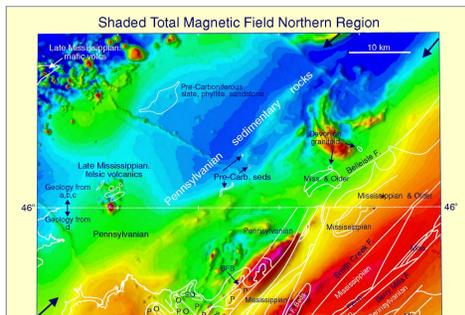
The 1st vertical derivative image of the southern region (Fig. 8) highlights short wavelength features of the magnetic field, which in turn clearly define shallower elements of the geology and the structural fabric of the region. Structural trends are dominantly northeast-southwest, except within a coastal strip where trends are east-northeast, and in the area of the Point Wolfe River pluton, the adjacent eastern margin of the Bonnell Brook pluton, and an intervening belt of Coldbrook Group, where trends are north-northeast. The zone of north-northeast trends may signify a major deformational event that truncated or modified more northeasterly trends to the west. The coastal tract is underlain mainly by the Coldbrook Group, which correlates with a swath of linear/circular magnetic anomalies that mimic the trends of its internal units. The patterns and wavelengths of these anomalies indicate possible compositional variations within units, unrecognized by geological mapping, and possible unmapped faults. The fabric of short, linear anomalies within the Point Wolfe River pluton also signals internal compositional variations and structure. Linear features that apparently transgress the pluton's southern boundary suggest its continuity at shallow depth beneath the Coldbrook Group. The older age of the pluton (616, 625 Ma) compared to the 548-559 Ma age of the group (McLeod et al., 1994) suggests an unconformable or shallow structural (e.g. thrust) relationship. An abrupt northeast termination of a residual total magnetic field anomaly associated with the Bayswater Volcanics is enhanced on the 1st vertical derivative image, and indicates control by northwest-trending faults.



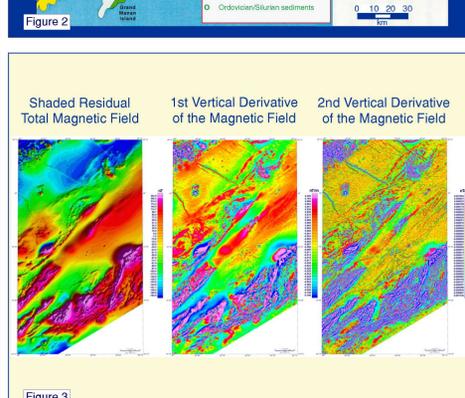
A picture of the first-order geological elements of the area is displayed in Figure 2 (from Potter et al., 1979; Ball, 1980; St. Peter, 1997; King and Barr, 2003a,b). Several linear, northeast-trending Neoproterozoic-Lower Palaeozoic terranes occur in the coastal area. From south to north these are the Caledonia [Late Neoproterozoic metasedimentary, metavolcanic and associated granitoid rocks (~620 Ma), together with younger (560-500 Ma) volcanic and sedimentary rocks], Brookville [Proterozoic - Cambrian metasedimentary, metavolcanic and gneissic rocks intruded by granitoid and minor mafic to ultramafic rocks], Kingston [Silurian metavolcanic and granitoid rocks intruded by numerous mafic dykes], New River [Neoproterozoic and Cambrian sedimentary and mafic to felsic igneous rocks], Mascarene [cover assemblage of Silurian to Early Devonian siliciclastic sedimentary and volcanic rocks intruded by numerous mafic dykes], and St. Croix [mainly Cambro-Ordovician to Silurian sedimentary rocks and minor volcanic rocks]. Most of the northern part of the area is covered by Late Devonian to Carboniferous sedimentary rocks, which rest unconformably on the aforementioned terranes. This northern sector also contains small inliers of Carboniferous volcanic and Pre-Carboniferous metamorphic and sedimentary rocks, and small Devonian granitoid intrusions.



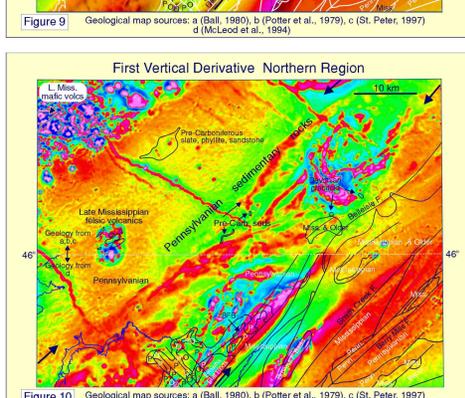
An image of the shaded total magnetic field of the northern part of the region with geological contacts superimposed is shown in Figure 9. The region is dominated by Carboniferous sedimentary rocks having low magnetic susceptibilities (Fig. 6), a property reflected in a generally smooth magnetic field, characterized by long wavelengths. A noticeable exception to this pattern is observed in the northwest corner of the area, where the magnetic field is perturbed by many short wavelength, intense anomalies, several being circular to oval-shaped. They are probably related to Late Mississippian basalts mapped locally in this area (St. Peter, 1997). A similarly perturbed field in the western part of the area, near latitude 46°, coincides with Late Mississippian felsic volcanic and intrusive(?) rocks. Conspicuous elements of the magnetic fabric are several narrow, elongate northwest-trending anomalies that doubtless signify diabase dykes. Large positive perturbations of the magnetic field in the south-central part of the area correlate with the Browns Flat Beds* where they break through Carboniferous sedimentary cover (McLeod et al., 1994). Recent mapping (S. Johnson, in preparation) indicates that these high likely signify Silurian volcano-sedimentary sequences and/or Cambro-Ordovician mafic and volcanic intrusive rocks, which have significant magnetic responses to the southwest.



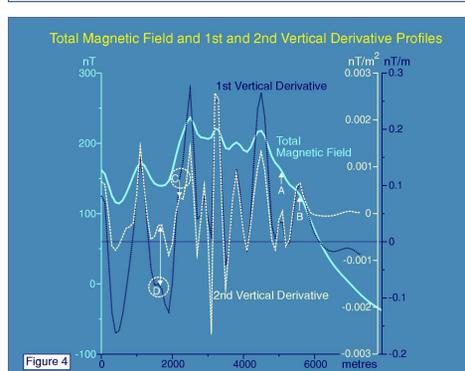
Data from the Marttown survey were released as a series of 1:50,000 scale maps of the residual total magnetic field, and 1st and 2nd vertical derivatives of the magnetic field (Kiss et al., 2004a,b). Images of these three representations of the magnetic field for the study area are shown in Figure 3. There is a noticeable variation in the amount of apparent detail in the images. The residual total magnetic field image is the least detailed, but importantly it indicates the relative intensity of the field, highlighting parts of the area underlain by strongly or weakly magnetized rock units. The 1st vertical derivative (vertical gradient) of the magnetic field presents a filtered version of the residual total magnetic field, in which shorter wavelength features of the field are emphasized at the expense of the longer wavelengths. For example, dyke-related anomalies in the northwest part of the area are much more prominent than counterparts in the residual total magnetic field. The 1st vertical derivative image provides a better representation of the structural fabric of a region, and is useful for mapping geological contacts, since at high magnetic latitudes (Earth's field steeply inclined) the zero contour falls close to contacts between rock units having contrasting magnetizations, provided the contact is steep (Hood, 1965; Hood and Teskey, 1989). In the Marttown survey area the Earth's inclination is roughly 70°, so the zero contour should provide an acceptable proxy for contact positions. Detail in the 1st vertical derivative image is further enhanced in the 2nd vertical derivative image, which is particularly useful for mapping structure within the Carboniferous sedimentary rocks.



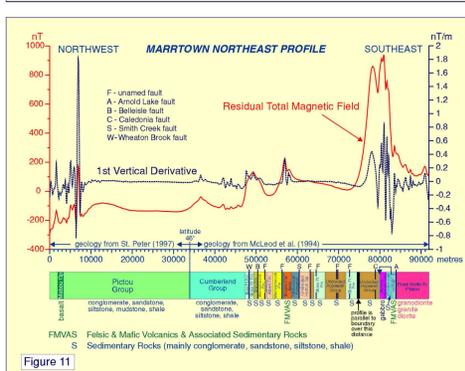
The contrast between the 1st vertical derivative image (Fig. 10), and that of the total magnetic field (Fig. 9) is remarkable for the increase in detail in the former. The region can be subdivided into four broad northeast-trending zones on the basis of contrasting textures of the magnetic features. In the northwest corner, where Late Mississippian basalts are present, the pattern is one of distinct, short, narrow linear features interspersed with circular features. This zone is flanked to the southwest by a zone characterized by a concentrated stippled pattern of low amplitude anomalies presumably reflecting the widely distributed Carboniferous sedimentary rocks in this area. Striking magnetic signatures of northwest-trending dykes cross this zone, as well as more subtle expressions of dykes near the north central margin of the area, which are barely discernible in the total magnetic field map (Fig. 9). This stippled zone is separated from a triangular zone having a similar stippled pattern, again attributed to Carboniferous sedimentary cover, by a central zone (running approximately between the two pairs of arrows) having a distinctly different pattern of anomalies. Here, many anomalies are linear/circular, much more extensive, and often significantly wider than those in the adjacent stippled zones. Even though the central zone is underlain mainly by Carboniferous sedimentary cover, the texture of the anomaly pattern is probably controlled by buried extensions of Lower Palaeozoic volcanics, Pre-Carboniferous sedimentary rocks, Silurian-Devonian mafic/ultramafic intrusions and Devonian granitoids, exposed in limited outcrops within the zone.



The differences between the residual total magnetic field, and the 1st and 2nd vertical derivatives of the magnetic field are demonstrated in profile format in Figure 4. The profile represents the southern end of a longer regional profile (Fig. 12) used for modelling. The resolving power of the 1st vertical derivative is illustrated by the transformation of two subtle positive perturbations (A and B) on the residual total magnetic field profile into two distinct positive features on the 1st vertical derivative profile. In a similar fashion the added resolution provided by the 2nd vertical derivative may be seen at points C and D. At C, a barely perceptible shoulder on the flank of a large positive 1st vertical derivative anomaly is transformed into a distinct positive signal on the 2nd vertical derivative profile. Meanwhile at D, a small 1st vertical feature is amplified in the 2nd vertical derivative profile. The 2nd vertical derivative map images some of the smallest wavelength and amplitude magnetic signals in the area, which are related to small contrasts in magnetizations. The Carboniferous sedimentary rocks, which cover much of the area, are characterized by such small magnetization contrasts, and thus the 2nd vertical derivative map provides a valuable tool for outlining these contrasts and the associated geological units. Contrasts in magnetization within and between plutonic and volcanic rocks are usually large enough to produce recognizable signatures in the total magnetic field, but recognition of the presence of the much smaller contrasts associated with sedimentary rocks generally requires a derivative image.



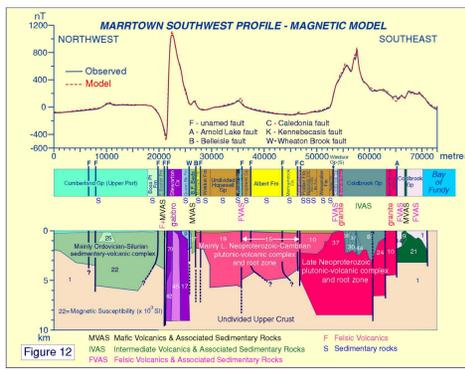
The variation in the residual total magnetic field (and 1st vertical derivative) across the area is illustrated in a NW-SE profile (Marttown northeast) in Figure 11 (see Sheets 1,2,3 for location). The total field varies by more than 1200 nT, being strongest in the southeast, where it peaks over the mafic/ultramafic Mechanic Settlement pluton. The field remains high immediately north of the pluton over Carboniferous sedimentary cover, suggesting the presence of the pluton at shallow depth. The field is significantly less intense, but still elevated to the southeast over the Coldbrook Group (volcanic and sedimentary rocks) and Point Wolfe River granitic pluton. Several short wavelength perturbations in the 1st vertical derivative profile over these units suggest compositional heterogeneity. North of the Mechanic Settlement high, over Carboniferous rocks, the field remains smooth until it is perturbed by a unit of Browns Flat Beds. Not far to the north another high is ascribed to the same unit, which surfaces about 1200 m along strike from the profile. Just south of latitude 46° another small high is probably related to buried Lower Palaeozoic volcanic and sedimentary rocks. From here to almost the north end of the profile, the field remains smooth over Carboniferous sedimentary rocks, but becomes extremely perturbed at the north end, probably because of the influence of Late Mississippian olivine basalts, which have been mapped locally in this area (St. Peter, 1997). The wider distribution of the perturbed magnetic field suggest that the basalts have a wider distribution than geological mapping indicates, and/or that they are present at shallow depth.



Critical to the analysis of magnetic data is knowledge of the magnetic properties of the rocks in an area. King and Barr (2003b) compiled magnetic susceptibility data for a large part of the coastal region of southern New Brunswick, based on approximately 2800 measurements on hand samples. Although their area (limited to the east by longitude 65° 45') overlaps only slightly with the present study area, the presence of common geological elements in both areas means that their data afford insight into the magnetic properties of several rock units in the present area. Information on the magnetic susceptibilities of several plutonic bodies is presented in Figure 5, which lists the name of the body, its age (McLeod et al., 1994), the principal sample lithologies, the number of samples, the average magnetic susceptibility (unit is 10⁻³ SI) and its standard deviation. For the Bonnell Brook and Point Wolfe River plutons, King and Barr (2003b) provided a series of mean values for different lithological components, but in Figure 5 only the range of these mean values is listed, along with the total number of samples comprising all the subgroups; standard deviation information is not presented. The selected plutons are assigned to three groups, which illustrate the broad differences among the magnetic properties of plutonic rocks. The first group is strongly magnetic (susceptibilities range from about 10 - 35 x 10⁻³ SI), the second group may be classed as weakly to moderately magnetic (generally from about 2.4 - 3.5 x 10⁻³ SI, though certain components of the Point Wolfe River pluton are <1 x 10⁻³ SI), and the third group is very weakly magnetized (<1 x 10⁻³ SI).

| Plutonic Body (Age) | Lithology | No. | k | SD |
|---|--|-----|------|-------|
| French Village quartz diorite (~538 Ma) | quartz diorite | 6 | 34.6 | 45.80 |
| Mechanic Settlement pluton (557 Ma) | diorite, gabbro | 24 | 22.8 | 31.11 |
| Upham Mountain pluton (554 Ma) | diorite, granite, syenogranite | 12 | 18.4 | 42.02 |
| Milkish Head pluton (520 Ma) | granodiorite | 5 | 11.0 | 2.72 |
| Point Wolfe River pluton (616, 625 Ma) | granite, granodiorite, diorite | 229 | 0.06 | 3.76 |
| Duck Lake pluton | gabbro | 3 | 3.63 | 3.92 |
| Bonnell Brook pluton (550 Ma) | granite, leucogranite, syenogranite, diorite | 62 | 2.43 | 3.01 |
| Hammond River pluton (438 Ma) | granite | 1 | 2.97 | |
| Centreton granite (438 Ma) | granite, gabbro | 22 | 0.88 | 2.56 |
| Emerson Creek pluton | granite | 2 | 0.09 | 0.01 |
| Millican Lake pluton (625 Ma) | granite | 2 | 0.07 | 0.02 |

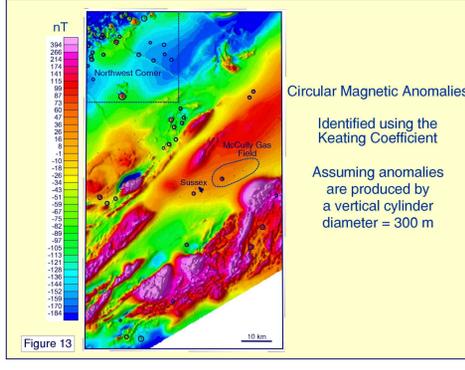
A model was derived from a second residual total magnetic field profile (Marttown southwest - see Sheets 1,2,3) crossing the area (Fig. 12). Its pattern of variations is very similar to that of the Marttown northeast profile. A strong positive signature over Neoproterozoic rocks (sedimentary-volcanic Coldbrook Group, Bonnell Brook pluton) in the southeast yields northward to a lower, smoother magnetic field over Carboniferous sedimentary cover, which is perturbed locally by a large positive anomaly over a belt of Lower Palaeozoic sedimentary-volcanic rocks intruded by the Silurian-Devonian Stewart Complex. Modelling was constrained by mapped geological contacts (McLeod et al., 1994), and reported magnetic susceptibilities (King and Barr, 2003b). The positive signature in the southeast is explained by the Coldbrook Group and Bonnell Brook pluton, and an underlying late Neoproterozoic plutonic-volcanic complex, modelled schematically as a continuation of the pluton. Further north, a Late Neoproterozoic-Cambrian plutonic-volcanic complex is modelled under Carboniferous sedimentary cover, based on a surface fault sliver of Late Neoproterozoic rocks, and occurrences of specific rock types along strike. A mainly Ordovician-Silurian sedimentary-volcanic complex is proposed under the Carboniferous at the northwest end of the profile. The Stewart Complex is modelled as a vertical body descending to a depth of about 9 km, and having large susceptibilities. The model is characterized by steep contacts and faults and rock units descending several kilometres into the crust, and is very similar to models presented by King and Barr (2003b) along strike to the southwest.



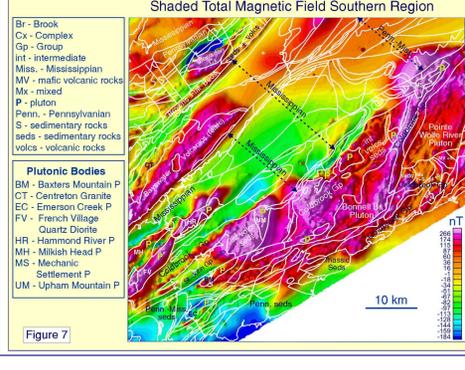
Magnetic susceptibilities of volcanic and sedimentary rock units are listed in Figure 6. Devonian-Carboniferous sedimentary rocks have notably very low mean susceptibilities (<0.25 x 10⁻³ SI). Nevertheless, they cannot be viewed as strictly non-magnetic, a conclusion supported by magnetic patterns over these rocks expressed in the 2nd vertical derivative map. Cambrian to Silurian units, comprising volcanic and/or sedimentary rocks, have somewhat higher susceptibilities, but would still be classed as weakly magnetized (mean susceptibilities are <1.5 x 10⁻³ SI), though Ordovician-Silurian mafic dykes in some of the same units are more strongly magnetized (susceptibilities range from about 3.9 to 6.9 x 10⁻³ SI). In general, the volcanic and sedimentary rocks comprising the Late Neoproterozoic Coldbrook and Broad River groups have magnetic susceptibilities that would categorize these groups as having weak to moderate magnetizations. King and Barr (2003b) present mean susceptibilities for a large number of subgroups in both of these groups; the range of the individual means is presented in Figure 6, but standard deviations are not listed. In the Coldbrook Group one subgroup comprising rhyolite and basalt yielded a mean susceptibility as high as 22.8 x 10⁻³ SI (9 samples). Mean susceptibilities for 12 other subgroups range from 0.04 - 7.37 x 10⁻³ SI, and of the 13 subgroups only 3 had means less than 2 x 10⁻³ SI. Subgroups (11) of the Broad River Group have mean susceptibilities ranging from 0.18 to 5.56 x 10⁻³ SI, but of these, 5 have mean susceptibilities <1 x 10⁻³ SI, so that the group as a whole is probably significantly more weakly magnetized than the Coldbrook Group.

| Rock Unit | Lithology | No. | k | SD |
|------------------------------|---|-----|------|-------|
| Carboniferous Undivided | sedimentary rocks | 1 | 0.23 | |
| Balls Lake Fm. (Penns.) | sedimentary rocks | 2 | 0.10 | 0.03 |
| Windsor Gp. (Miss.) | sedimentary rocks | 5 | 0.22 | 0.71 |
| Kennebecasis Fm. (Miss.) | sedimentary rocks | 2 | 0.15 | 0.06 |
| Fairfield Fm. (Devonian) | lithic tuff | 11 | 0.24 | 0.16 |
| Williams Lake Fm. (Ord-Sil) | mafic dykes, felsic dykes, andesitic & dacitic tuff | 13 | 3.93 | 6.99 |
| | mafic & felsic dykes, dacite | 4 | 0.09 | 0.08 |
| | andesitic & dacitic tuff | 74 | 1.48 | 4.64 |
| Bayswater Fm. (Ord-Sil) | volcanics | 81 | 0.89 | 2.39 |
| | mafic dykes | 16 | 6.83 | 11.92 |
| St. John Gp. (Camb-Ord) | siltstone | 10 | 0.23 | 0.11 |
| Browns Flat Fm. (Cambrian) | mafic volcanics, sedim. rocks | 1 | 0.43 | |
| Coldbrook Gp. (548-559 Ma) | basalt, rhyolite, tuff, felsite, mafic & felsic dykes, dacite, conglomerate, volcanic rocks | 9 | 22.8 | 47.26 |
| | andesite, basalt, tuff, phyllite, slate, arkose, greenstone, sandstone | 513 | 0.04 | -7.37 |
| Broad River Gp. (600-634 Ma) | Late Neoproterozoic | 618 | 0.18 | 5.56 |

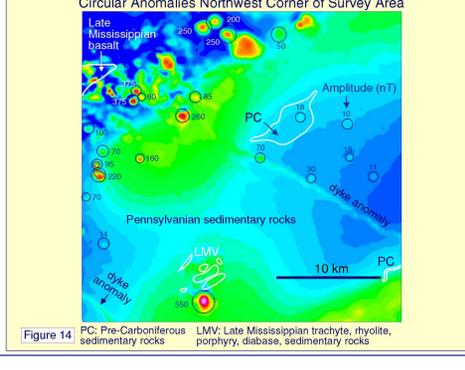
Scattered throughout the study area are many circular or approximately circular anomalies having diameters measured in hundreds of metres, and only rarely exceeding 1000 m. Keating (1995) has documented a rapid automatic method for locating circular anomalies. The method assumes that a vertical cylinder produces the anomalies. Circular pattern recognition is achieved by calculating a first-order regression between a theoretical cylinder anomaly and the observed data within a moving window. Positions of circular anomalies meeting the desired regression criteria are recorded. Circular anomalies detected within the area assuming a cylinder diameter of 300 m are shown in Figure 13. The initial output was examined, and anomalies deemed unacceptable for reason of shape were rejected. To be sure of detecting circular anomalies of all diameters the method should be run several times using a range of cylinder diameters. Figure 13 illustrates results for only a single diameter, nevertheless visual inspection of the magnetic map indicates that a large percentage of circular anomalies has been outlined. Given the interest in circular anomalies associated with kimberlite pipes, the presence of such anomalies certainly piques interest, but it is cautioned that the development of diamondiferous pipes requires the presence of an underlying appropriate lithosphere. It must be noted also that some anomalies may be related to cultural features, e.g. barns, silos, bridges, and in this particular area, steel casings in drill-holes. Circular anomalies in the northwest corner of the area, and the area of the McCully gas field are examined in more detail in the next two figures and related text.



A shaded residual total magnetic field image of the southern part of the study area, with geological boundaries (McLeod et al., 1994) superimposed, is shown in Figure 7. It is characterized by the strongest magnetic anomalies in the study area, which coincide with Neoproterozoic-Lower Palaeozoic terranes (Fig. 2). Mississippian and Pennsylvanian sedimentary rocks correlate with a weaker, smoother and less perturbed magnetic field. The Caledonia terrane, consisting mainly of the Neoproterozoic Coldbrook Group (intermediate volcanic rocks), lesser mafic and felsic volcanic rocks, and a variety of sedimentary rocks, and several Neoproterozoic plutonic bodies, produces a large area of strongly positive magnetic field. Measured magnetic susceptibilities of the Coldbrook Group (Fig. 6) and Point Wolfe River and Bonnell Brook plutons (Fig. 5) predict generally weak to moderate induced magnetizations, yet strong magnetic signatures in places suggest that susceptibilities are locally significantly higher. The large susceptibility of the Mechanic Settlement pluton is reflected in the highest magnetic field in the study area. Plutons in the Brookville (French Village, Hammond River, Milkish Head) and Mascarene (Stewart Complex) terranes also produce strong magnetic anomalies. The Kingston terrane (comprising mainly Bayswater Volcanics) produces a strong magnetic high that is abruptly terminated near its northeastern margin. It is replaced by a more diffuse high along strike, that suggests continuity of the terrane towards the northeast at depth. Measured susceptibilities of volcanic rocks are low, but are notably higher for the prolific mafic dykes that intrude them (Fig. 6).



Many circular anomalies occur in the northwest sector of the Marttown survey area (Fig. 14). Diameters range from about 500 to 1300 m, and amplitudes from about 10 to 375 nT. The prevailing rock types in the area are Pennsylvanian sandstones, conglomerates, siltstones, mudstones, and shales (St. Peter, 1997). However, a minor development of Late Mississippian olivine basalt, and an adjacent perturbed pattern of relatively intense positive circular and irregularly linear anomalies, indicate a wider distribution of igneous rocks. The circular aspect of several anomalies (amplitudes 50 to 375 nT), suggests an association with feeder pipes related to volcanic activity. Anomalies indicating the presence of hitherto unmapped dykes in the area support this conclusion. A group of 5 circular anomalies having significantly lower amplitudes (10 to 30 nT) in the eastern part of the area, where the field is comparatively smooth, may have a different origin. The lower amplitudes and location mainly within sedimentary rocks suggest that they are produced by metal casings of drill-holes related to exploration for hydrocarbons or potash deposits, which occur elsewhere in the region. This view is contradicted by the fact that none of the few drill-hole logs listed in the New Brunswick Natural Resources, Minerals, Policy and Planning Division's core hole data base (www1.pnb.ca/0078/GeoscienceDatabase/index.htm) coincides with an anomaly. New Brunswick Natural Resources geologists familiar with the area believe that these anomalies may be related to geological intrusions (Malcolm McLeod, Susan Johnson, personal communication, 2004).



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