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Chapter 2: "Crustal structure of Wrangellia and adjacent terranes inferred from geophysical studies along a transect through the northern Talkeetna Mountains" (J.M.G. Glen, J. Schmidt, L. Pellerin, D.K. McPhee, and J.M. O'Neill) in ***SPE431: Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska*** *(K.D. Ridgway, J.M. Trop, J.M.G. Glen, and J.M. O'Neill)*

The Geological Society of America
Special Paper 431
2007

Crustal structure of Wrangellia and adjacent terranes inferred from geophysical studies along a transect through the northern Talkeetna Mountains

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ABSTRACT

Recent investigations of the Talkeetna Mountains in south-central Alaska were undertaken to study the region's framework geophysics and to reinterpret structures and crustal composition. Potential field (gravity and magnetic) and magnetotelluric (MT) data were collected along northwest-trending profiles as part of the U.S. Geological Survey's Talkeetna Mountains transect project. The Talkeetna Mountains transect area comprises eight 1:63,360 quadrangles (~9500 km^2) in the Healy and Talkeetna Mountains 1° × 3° sheets that span four major lithostratigraphic terranes (Glen et al., this volume) including the Wrangellia and Peninsular terranes and two Mesozoic overlap assemblages inboard (northwest) of Wrangellia. These data were used here to develop 2½-dimensional models for the three profiles.

Modeling results reveal prominent gravity, magnetic, and MT gradients (~3.25 mGal/ km, ~100nT/km, ~300 ohm-m/km) corresponding to the Talkeetna Suture Zone—a first-order crustal discontinuity in the deep crust that juxtaposes rocks with strongly contrasting rock properties. This discontinuity corresponds with the suture between relatively dense magnetic crust of Wrangellia (likely of oceanic composition) and relatively less dense transitional crust underlying Jurassic to Cretaceous flysch basins developed between Wrangellia and North America. Some area of the oceanic crust beneath Wrangellia may also have been underplated by mafic material during early to mid-Tertiary volcanism.

The prominent crustal break underlies the Fog Lakes basin approximately where the Talkeetna thrust fault was previously mapped as a surface feature. Potential field and

Glen, J.M.G., Schmidt, J., Pellerin, L., McPhee, D.K., and O'Neill, J.M., 2007, Crustal structure of Wrangellia and adjacent terranes inferred from geophysical studies along a transect through the northern Talkeetna Mountains, *in* Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska: Geological Society of America Special Paper 431, p. 21–41, doi: 10.1130/2007.2431(02). For permission to copy, contact editing@geosociety.org.

MT models, however, indicate that the Talkeetna Suture Zone crustal break along the transect is a deep (2–8 km), steeply west-dipping structure—not a shallow east-dipping Alpine nappe-like thrust. Indeed, most of the crustal breaks in the area appear to be steep in the geophysical data, which is consistent with regional geologic mapping that indicates that most of the faults are steep normal, reverse, strike-slip, or oblique-slip faults. Mapping further indicates that many of these features, which likely formed during Jurassic and Cretaceous time, such as the Talkeetna Suture Zone have reactivated in Tertiary time (O'Neill et al., 2005).

Keywords: south-central Alaska, Talkeetna Mountains, crustal structure, geophysical models, mineral resources, gravity, magnetics, magnetotellurics.

INTRODUCTION

The geology of south-central Alaska records the Mesozoic to Neogene accretion of major and minor terranes to the North American continental margin (Plafker and Berg, 1994) with the northern-most margin of allochthonous or accreted terranes most commonly defined by the Denali fault zone (Howell et al., 1985). The northern Talkeetna Mountains occupy a unique position within this accreted margin that spans several major and minor stratigraphic terranes, preserving both an overlap assemblage and the northern- and western-most known extents of the Wrangellia terrane. This study seeks to resolve structures between and within these terranes to define the number, type, and character of crustal breaks throughout the study area but particularly in the transition zone spanning the suture of Wrangellia to North America.

Until now, a detailed assessment of the extent of these terranes, the locations of their boundaries, and the presence of significant intraterrane structures and intrusions has not been possible. These issues can now be addressed due to combined geophysical data acquisition and geologic mapping efforts recently undertaken in the Talkeetna Mountains. The integration of gravity, magnetic, magnetotelluric (MT), structural, and geologic data concentrated along a transect (Talkeetna Mountains transect) that spans this tectonically critical area (Figs. 1, 2, 3) provides a relatively detailed picture of the crustal structure beneath and adjacent to Wrangellia in south-central Alaska.

The potential field and MT data are used to define the geometry and character of terrane-bounding (first-order) structures, as well as second-order structures internal to tectonostratigraphic terranes (TST). By discerning differences in the compositional character and structural style of crustal blocks, geophysical data and resulting models aid in deciphering Late Triassic to Neogene plate interactions involving the suturing of Wrangellia to the continental margin and can be used to distinguish between competing tectonic models. Being effective at defining the subsurface depth and extent of igneous rocks, geophysical methods are also invaluable to understanding the magmatic history of the region.

Physiography

The Talkeetna Mountains form an elevated block situated between the Denali and Border Ranges faults. Two prominent basins bound the mountains—the Susitna River basin to the west and the Copper River basin to the east (Fig. 1). The region varies from rugged glaciated mountains in the highlands, with summit peaks between 2000 and 3000 m, to low benches situated along the Susitna River. Many of the larger rivers in the area (e.g., the Susitna, Copper, and Delta rivers), which have deeply incised canyons, likely predate Neogene uplift of the mountains they cut.

Modern physiography, including drainage, lakes, ridges, and valleys, is strongly influenced by the structural geology of the area. Evident is a pervasive N20–40°E structural fabric, defined by several prominent geologic and physiographic features, including the trend of the major tectonostratigraphic terranes (Fig. 1C).

Geology

South-central Alaska (Fig. 2) consists of an assemblage of diverse Paleozoic and Mesozoic tectonostratigraphic terranes, including intraoceanic and possible continental arcs, accretionary prisms, flysch basins, oceanic plateaus, and large blocks of oceanic crustal rocks (Berg et al., 1972; Jones et al., 1972; Berg et al., 1978; Plafker and Berg, 1994; Nokleberg et al., 1994). Oceanic crustal rocks are remnants of Devonian to Early Jurassic marginal ocean basins. Due to subduction during Jurassic and Cretaceous time, these marginal seas closed as intraoceanic terranes converged toward the continental margin, and oceanic rocks were eventually obducted to North America.

The two major terranes in the Talkeetna Mountains, the Wrangellia and Peninsular terranes, were well south of their present position (~30°) in the Late Triassic (Hillhouse and Coe, 1994), and may have amalgamated by Middle or Late Jurassic (Csejtey et al., 1982). Though probably still south of their present position, they docked with North America no later than the middle Cretaceous (Grantz et al., 1991). Following accretion, oblique subduction moved blocks of the Wrangellia and Peninsular terranes northward along the continental margin via strike-slip faults such as the Fairweather fault system. During mid-Cretaceous to early Tertiary time, several suites of plutons and volcanic fields stitched the assemblage of southern Alaska terranes.

Due to the relatively remote nature of the Talkeetna Mountains, geologic mapping in the area has been regional and reconnaissance in nature. Existing regional coverage includes work by Csejtey and Griscom (1978), and Csejtey et al. (1978). More

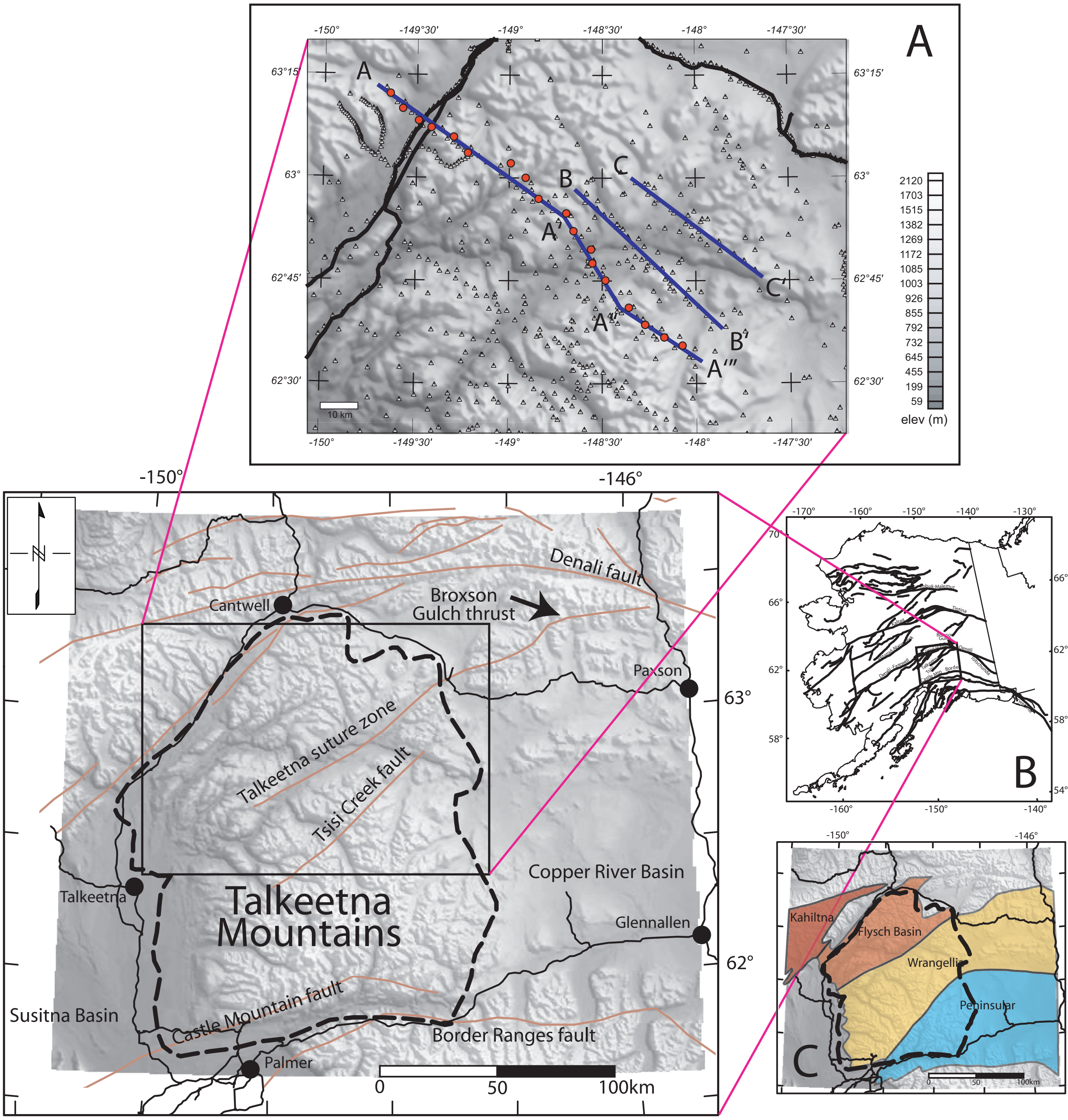

Figure 1. Topographic map of south-central Alaska showing the main physiographic features (roads [thin black lines], towns [black circles], and faults [red lines]) in the Talkeetna Mountains region (dashed outline); (A) shaded relief topographic map of study area with geophysical profiles (blue lines), gravity stations (triangles), and MT stations (red circles); (B) state index map; (C) regional tectonostratigraphic terrane map (after Glen et al., this volume). Figure 1A corresponds with area shown in Figures 5 and 6.

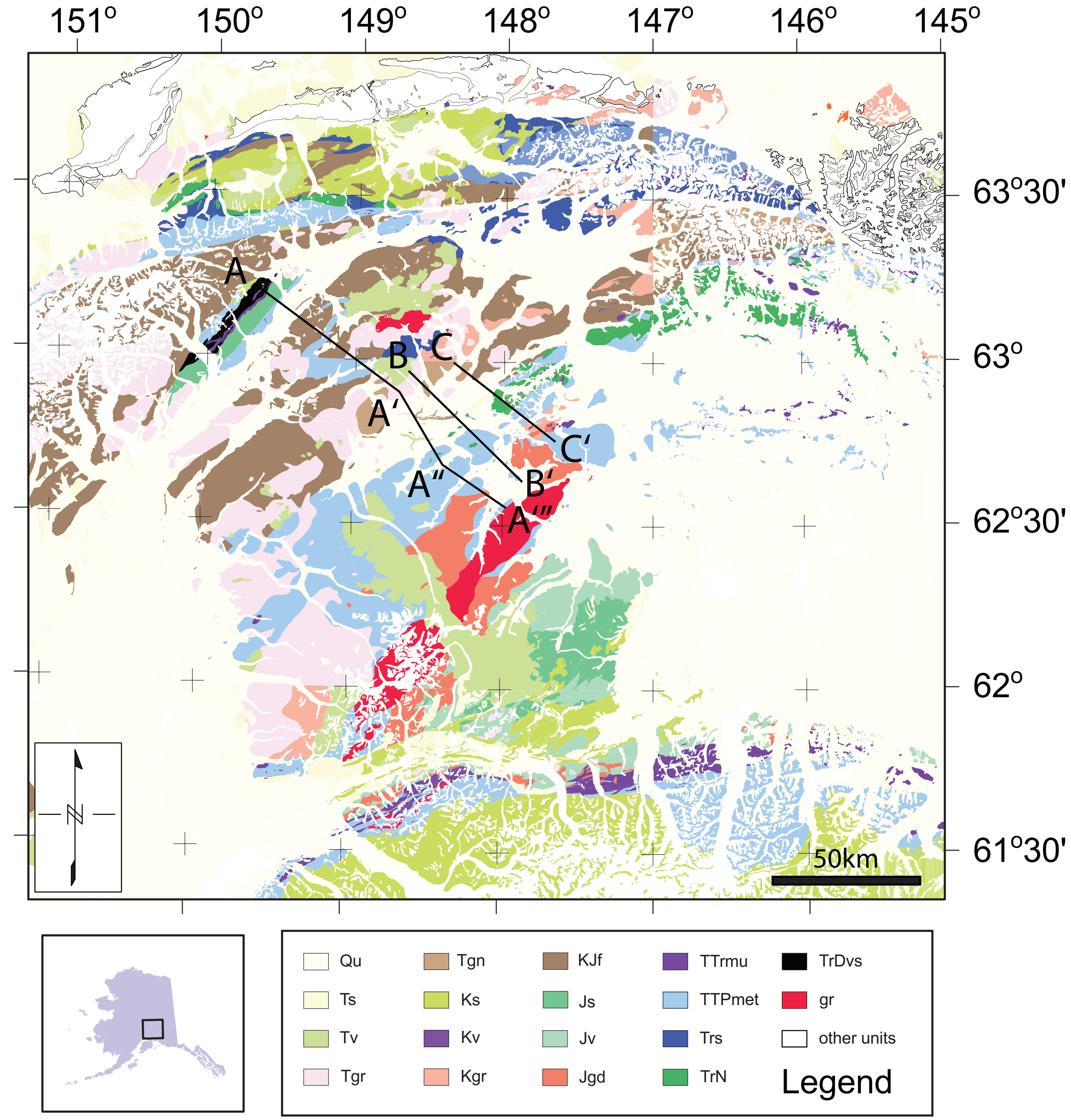

Figure 2. Regional geologic map of the Talkeetna Mountains and surrounding region (simplified from Wilson et al., 1998) showing potential field profiles (A–A′–A″–A‴, B–B′, and C–C′). Qu = Quaternary sediments, undifferentiated; Ts = Tertiary nonmarine clastic sedimentary rocks; Tv = Tertiary volcanic rocks; Tgr = Tertiary granitoid intrusive rocks; Tgn = Tertiary gneiss and granitoid intrusive rocks, undifferentiated; Ks = Cretaceous sedimentary rocks; Kv = Cretaceous volcanic rocks; Kgr = Cretaceous granitoid intrusive rocks; KJf = Jurassic to Cretaceous flysch, shale, sandstone, and conglomerate; Js = Jurassic sedimentary rocks; Jv = Jurassic volcanic and volcaniclastic rocks; Jgd = Jurassic granodiorite; TTrmu = Tertiary(?) to Triassic mafic and ultramafic rocks; TPmet = Tertiary to Permian metamorphic rocks and mélange, undifferentiated; Trs = Triassic sedimentary rocks; TrN = Triassic Nikolai Greenstone and gabbros; TrDvs = Triassic to Devonian Chulitna terrane volcanic and sedimentary rocks; gr = granitoid rocks, undifferentiated.

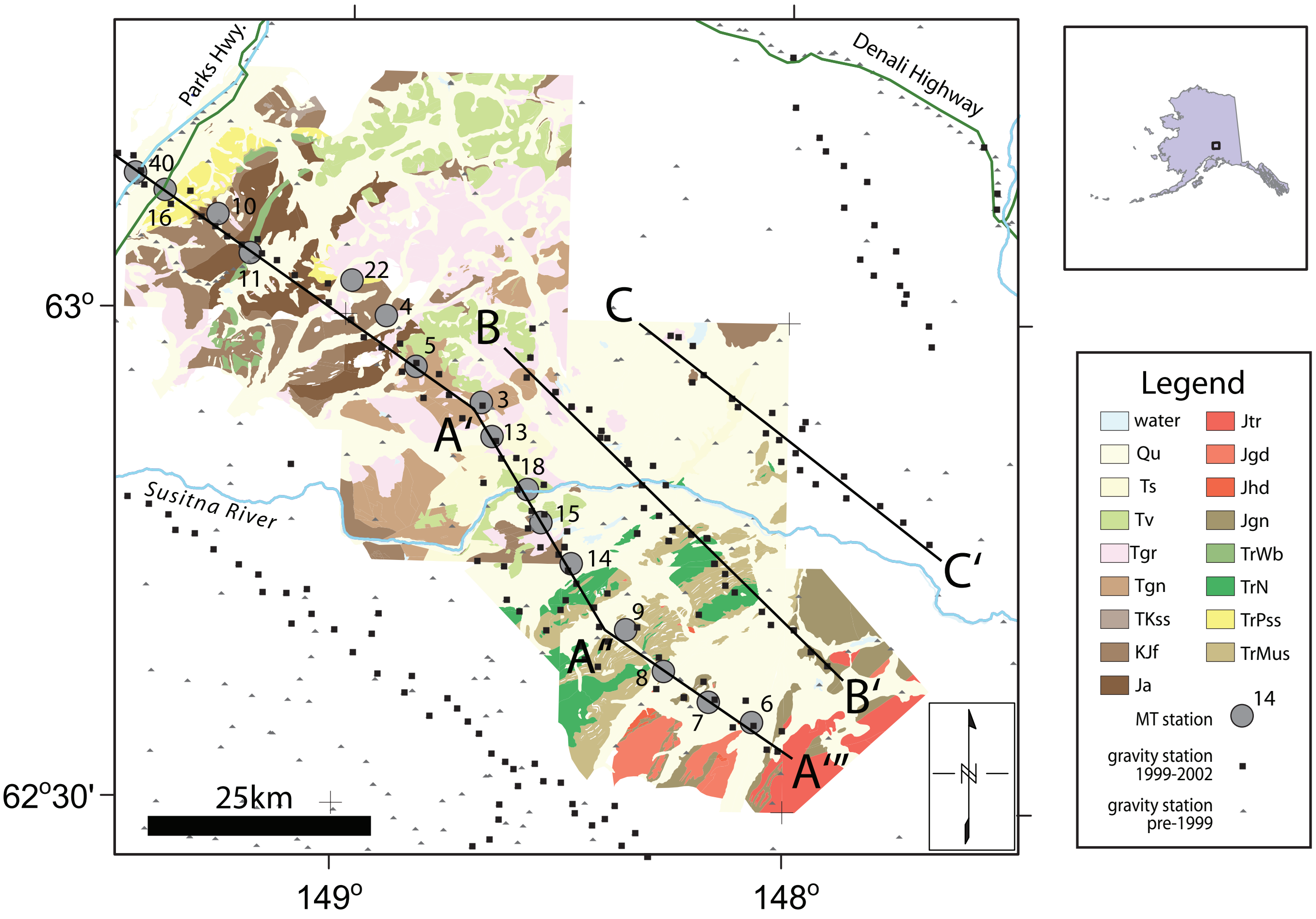

Figure 3. Simplified geologic map along a transect through the northern Talkeetna Mountains showing gravity (squares (1999–2000) and triangles) and MT stations and potential field profiles (black lines A–A′, B–B′, and C–C′). Qu = Quaternary sediments, undifferentiated; Ts = Tertiary nonmarine clastic sedimentary rocks; Tv = Tertiary volcanic rocks; Tgr = Tertiary granitoid intrusive rocks; Tgn = Tertiary gneiss and granitoid intrusive rocks, undifferentiated; TKss = Tertiary or Cretaceous sandstone; KJf = Jurassic to Cretaceous flysch, shale, sandstone, and conglomerate; Ja = Jurassic(?) argillite; Jtr = Jurassic trondjhemite; Jgd = Jurassic granodiorite; Jhd = Jurassic hornblende diorite; Jgn = Jurassic gneiss; Trwb = Triassic basalts of Whale Ridge; TrN = Triassic Nikolai Greenstone and gabbros; TrPss = Permian(?) to Triassic quartzose sedimentary rocks; TrMus = Mississippian to early Triassic siliceous and calcareous sedimentary rocks. Geology modified from Wilson et al., 1998, and unpublished U.S. Geological Survey mapping.

recent geologic studies are of limited scope or extent (e.g., Hardy, 1987; Smith et al., 1988; Clautice, 1990; Werdon et al., 2001; Schmidt et al., 2003). Recent 1:100,000-scale mapping by the U.S. Geological Survey along a transect through the northern Talkeetna Mountains (Figs. 1, 2) provides the most detailed geologic information to date from the Talkeetna Mountains region (e.g., Eastham and Ridgway, 2002; O'Neill et al., 2003).

Regional Faults and Structures

Bounding the Talkeetna Mountains to the north and south are the Denali and Castle Mountains fault zones (Fig. 1), respectively, which are two of a series of subparallel arcuate, right-lateral faults that crosscut southern Alaska. These faults, which accommodate stresses imposed on the western edge of North America by current motion and oblique subduction of the Pacific plate past the North American plate, may be successors to older structures that predate the Late Cretaceous to middle Eocene development of the southern Alaska orocline (Glen, 2004).

Aside from these major dextral shear zones, most faults that cross the study area are northeast trending, parallel to the strike of rock units and structures and the trend of tectonostratigraphic terranes in this part of south-central Alaska. Although many of these structures, including the Talkeetna Suture Zone Creek, Broad Pass graben, and Tsisi Creek fault, are apparently major sutures formed early in the history of accretion of the Wrangellia and Peninsular terranes to North America (in the Late Mesozoic), there is strong evidence they were repeatedly reactivated in Tertiary time (O'Neill et al., 2005).

Tectonostratigraphic Terranes

The study area preserves evidence of a Mesozoic through present history of collisional tectonics, with the earliest recognized terrane collision being the Jurassic to Cretaceous docking of Wrangellia. The history of Wrangellia's fragmentation and suture to the North American margin is recorded in a series of overlap assemblages (Gravina, Nutzotin, North Talkeetna, Kahiltna) developed along its leading margins (Eastham and Ridgway, 2002; Ridgway et al., 2002; Trop et al., 2002). Other accreted terranes previously interpreted in the Talkeetna Mountains as part of the continuing accretion of the Alaska margin include the Clearwater, Chulitna, Susitna, Broad Pass, West Fork, and Peninsular terranes (Jones et al., 1972; Howell et al., 1985; Nokleberg et al., 1994).

Four major tectonostratigraphic terranes and overlap assemblages that span the transect area are (from northwest to southeast): flysch basin deposits crosscut by Cretaceous and Tertiary plutons, the Wrangellia Terrrane, and the Peninsular Terrane (Figs. 1C, 2). The flysch is subdivided into two distinct depositional basins (Ridgway et al., 2002). The former Susitna and Broad Pass terranes are now included in the southeastern flysch basin, and the Chulitna and West Fork terranes lie between the two flysch basins.

The Peninsular terrane occurs in the extreme southeast portion of the study area. It consists of Paleozoic and Mesozoic metaigneous and metasedimentary rocks, the distinctive Late Triassic to Early Jurassic (205–190 Ma) Talkeetna volcanic arc, and Early Jurassic batholithic rocks (including tonalite, trondjhemite, and granodiorite) interpreted as the roots to the Talkeetna arc (Nokleberg et al., 1994).

The Late Jurassic to Late Cretaceous flysch overlap assemblage (formerly grouped into the Kahiltna flysch) has recently been recognized (Ridgway et al., 2002) to have been deposited in two separate basins. The Kahiltna flysch basin to the northwest of Broad Pass contains Late Jurassic to Late Cretaceous material derived from North American sources shed toward the southeast. The North Talkeetna flysch basin (southeast of Broad Pass), previously included as part of the Kahiltna flysch, includes a Late Triassic basement and Late Jurassic to Early Cretaceous sediments derived from Wrangellia and shed toward the northwest.

Wrangellia in the transect area consists of a sequence of Mississippian to Middle Triassic fine-grained, quartz-rich sedimentary rocks, volcanic rocks, and shallow marine limestones. These are overlain by the flood basalts of the distinctive Middle to Late Triassic Nikolai Greenstone and intruded by Nikolai correlative gabbroic sills and by a Middle Jurassic plutonic complex of dominantly intermediate composition.

All of these major terranes were subsequently punctuated by mafic to felsic composition volcanic rocks and associated hypabyssal intrusions during Tertiary time.

GEOPHYSICS

Geophysical methods allow imaging of subsurface structure over large tracts of land and are particularly useful for regional studies, especially large, poorly mapped, and inaccessible regions like the Talkeetna Mountains. Variations in gravity, magnetics, and electromagnetics occur due to lateral contrasts in rock density, magnetic (induced and remanent magnetizations), and electrical resistivity properties, respectively. Rock-property contrasts may occur within a rock unit, such as a lateral facies change at geologic structures such as faults and folds, or at contacts with other units. The geometry and depth to sources, the character of the geomagnetic field, and the rock properties of sources all determine the character of a source's potential field anomaly. Despite the complexity of potential fields and their sources, gravity and magnetic data can be used to resolve the geometry and origin of sources, particularly when combined with other geologic constraints such as the regional tectonic regime, surface geology, and electrical and seismic data.

Data

One hundred and forty new gravity stations were collected in 1999–2001 along three profiles (A, B, C, Fig. 1) in the mapped transect and combined with existing regional data to provide roughly 2 km station spacing along the profiles. Magnetic data employed in this study were compiled mainly from four regional aeromagnetic surveys (Glen et al., this volume). MT data were collected in 2000–2002 at 23 stations along a single 105 km profile (profile A, Fig. 1), although only 18 stations were of high enough signal quality for resistivity modeling. Gravity and magnetic profiles were drawn from grids generated from these data. To aid in modeling of the potential field data, over 300 magnetic susceptibility and specific gravity measurements were made on rock samples from the area and combined with rock data from previous surveys. For details on gravity, magnetic, and rock property data, refer to Glen et al. (this volume), Morin and Glen (2002, 2003), and Sanger and Glen (2003).

Gravity

Gravity data were compiled from a variety of sources (Morin and Glen, 2002, 2003). The gravity map derived from these data reflects anomalies produced by contrasts in crustal density. Generally, long-wavelength anomalies with smooth gradients originate from sources at depths greater than sources of short-wavelength anomalies with steep gradients. Although short-wavelength anomalies must originate from shallow depths, long-wavelength anomalies can also be produced by shallow, thin sources with large lateral extent that have gently sloping sides. Generally mafic-to-ultramafic igneous, carbonate, and crystalline-basement rocks are associated with positive gravity anomalies, whereas volcanic and sedimentary rocks are associated with gravity lows with respect to average continental crustal densities.

In order to obtain gravity data reflecting lateral variations in crustal density, raw gravity measurements were reduced using standard gravity reduction methods (Dobrin and Savit, 1988; Blakely, 1995). These reductions remove the effects of elevation, topography, and the total mass, rotation, and ellipsoidal shape of Earth, yielding the complete Bouguer gravity anomaly (CBA). Although the CBA reveals lateral density variations at short wavelength scales, it does an inferior job isolating longer-wavelength features because these are often masked by broad anomalies due to deep crustal roots that isostatically compensate topographic loads. The isostatic correction attempts to correct for the effects of compensating masses.

Magnetics

Magnetic data were compiled from four main surveys: three flown at 1000′ above ground with lines oriented north-south and spaced 1 to 3/4 mile apart (Saltus and Simmons, 1997; surveys AK08, AK11, 4093), and one recently acquired high-resolution survey composite, flown 200′ above ground with lines oriented north-south and spaced 1/4 mile apart, covering the northwest part of the northwest segment of profile A (Burns, 2002). Data for profiles B, C, and the central and southeast segments of profile A were derived from a grid made from digitized contours of the original survey maps (survey AK11; Saltus and Simmons, 1997).

Variations in the magnetic field arise largely from contrasts in the magnetic properties of rocks. These contrasts can be due to a number of different sources including crustal structures, juxtaposing different rock types, metamorphism and alteration, variations in remanent magnetization, and variations in the concentration and type of magnetic minerals within rock units.

Although the magnetic field strength depends on both induced and remanent crustal magnetization, it is often assumed that it is sufficient to consider only induced magnetizations because in many cases remanent overprints lie close to the induced field direction and the magnitude of remanence is often negligible. Remanence may, however, have a significant effect, particularly in the case of strongly magnetic units such as mafic and ultramafic rocks like the Nikolai Greenstone and associated intrusive units.

An important effect on the character of magnetic anomalies is the depth to the source. The shallower the depth of a body, the higher the amplitude, the shorter the wavelength, and the sharper the gradients of its anomaly. Generally, magnetic highs result from mafic igneous and crystalline basement rocks, whereas lows are produced by felsic igneous, sedimentary, or altered crystalline rocks. Igneous outcrops not associated with observed magnetic anomalies may be thin, contain low concentrations of primary magnetic minerals, or have lost magnetic minerals due to alteration.

Magnetic variations can also arise from deviations of the aircraft from the designated draped or fixed elevation. This is a potential problem in interpreting older surveys where aircraft elevation data were not available. The effect is most significant in steep or widely varying terrain and can result in accentuating anomalies over ridge crests and smoothing anomalies over valleys.

Magnetotellurics

The sole MT profile (profile A, Fig. 1) crosses the Talkeetna Mountains with an orientation of 310°, which is roughly perpendicular to the strike of the Talkeetna Suture Zone. Twenty-three MT stations and seven audio-MT (AMT) stations were acquired during the summers of 2000 (Sampson and Rodriguez, 2000), with supplement acquisition in the summers of 2001 and 2002. The audio-MT data were not of sufficient quality to significantly increase the MT sounding range of 0.002–500 seconds and were not used for the resistivity modeling reported here. The MT array was oriented such that the xy mode is identified as transverse magnetic (TM)—electric field perpendicular to strike and parallel to the profile direction—and the xy as transverse electric (TE)—magnetic field perpendicular to strike. The sites are evenly spaced along profile A, but data quality was not uniform. Only 18 sites were determined to be of high enough quality to be used for modeling. These sites are shown in Figure 1.

The MT method can provide images of the electrical resistivity to deep crustal and upper mantle depths (Vozoff, 1991; Wannamaker, 1999). Electrical resistivity of the crust provides information on primary rock units and structures (e.g., sedimentary facies, lithologic contrasts, and major faults), geochemical fluxes (hydrothermal alteration, remobilized graphite, and sulfides), and the thermal regime (prograde or melt-exsolved fluids, crustal or upper-mantle melts, mineral semiconduction) of the crust. Figure 4 shows typical resistivity values for common earth materials (Palacky, 1988).

Regional Geophysics

Gravity and magnetic maps of the Talkeetna Mountains (Figs. 5 and 6, respectively) reveal a dominant northeast-trending fabric through the central Talkeetna Mountains that reflects the orientation of major rock units, structures, and tectonostratigraphic terranes (Glen et al., this volume). Combined magnetic and gravity highs within Wrangellia presumably reflect mafic and ultramafic rocks associated with the Triassic Nikolai Greenstone. Sharply defined northeast-trending linear edges of magnetic anomalies suggest that the magnetic sources producing the anomalies are likely fault bounded. Many fault traces, which are only inferred on the basis of their weak surface expression, can be clearly defined and traced geophysically.

In the vicinity of the transect the most striking geophysical feature, comprised of prominent gravity, magnetic, and MT gradients, is located along the Talkeetna Suzure Zone and coincides with the northernmost mapped extent of the Nikolai Greenstone on the Wrangellia terrane. The geophysical gradients (~3mGal/km, 100nT/km, and 300 ohm/m-km) across the suture zone reflect the

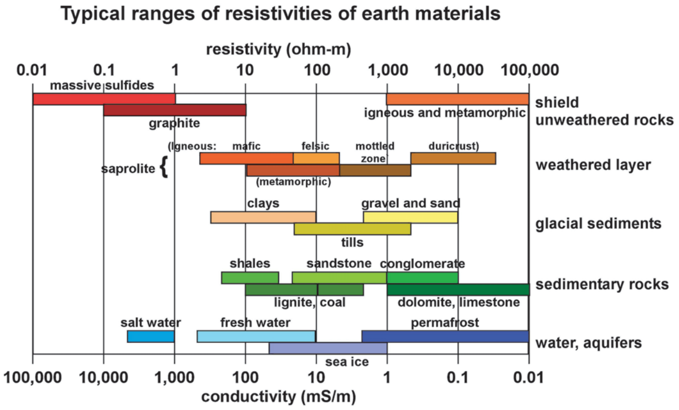

Figure 4. Typical resistivity values for earth materials (after Palacky, 1988).

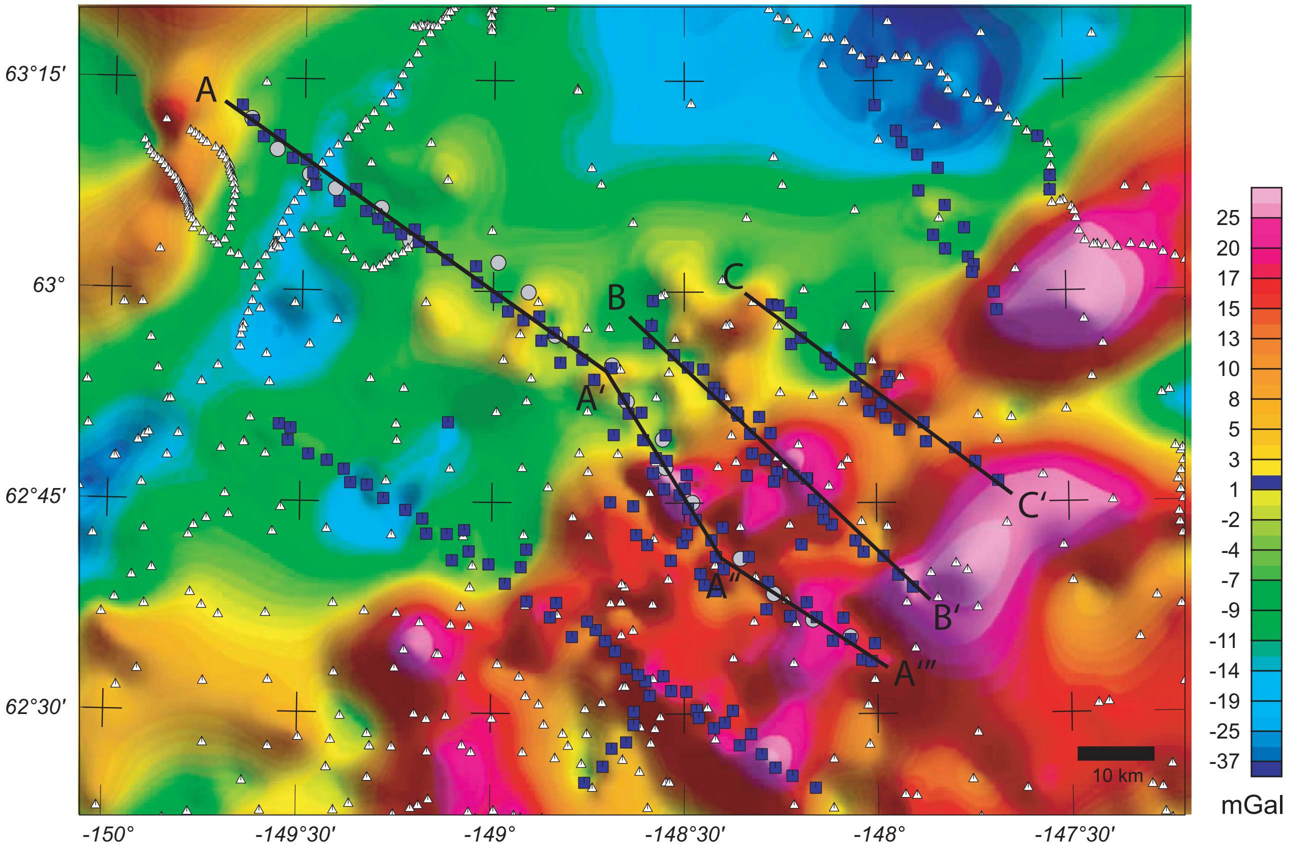

Figure 5. Isostatic gravity map showing gravity (triangles and squares) and MT (gray circles) stations and potential field profiles (black lines). Gravity data, collected in 1999–2001 during the Talkeetna Mountains transect project, are shown by the black squares.

contrast between relatively low-density, weakly magnetic flysch deposited on the transitional lower crust to the northwest (characterized by low and subdued potential fields) and the dense, magnetic mafic and ultramafic oceanic lower crust of Wrangellia to the southeast (with strong and highly variable potential field anomalies).

Profiles

Three subparallel, northwest-trending potential field profiles in the vicinity of the mapped Talkeetna transect (Fig. 3) are modeled and discussed here. The location of the potential field profiles were chosen such that they (1) lie across the highest density of gravity data, (2) coincide with magnetotelluric and geologic profiles, and (3) lie roughly perpendicular to the strike of geologic units.

In addition to gravity and magnetics, MT data were collected along the longest of the three profiles (profile A). Profile A is subdivided into three segments for the potential field modeling in order to best utilize the gravity data coverage. The northwest segment of profile A extends across from the Kahiltna flysch basin in the northwest to the North Talkeetna flysch basin in the southeast. The northwest segment crosses the Chulitna and West Fork terranes, Broad Pass, and the area of the former Susitna terrane. The central segment of profile A crosses the contact (Talkeetna Suture Zone) between the North Talkeetna flysch basin and Wrangellia. The southeast segment of profile A lies entirely within the expanded Wrangellia terrane (Glen et al., this volume). Profiles B and C both span the contact between Wrangellia and the North Talkeetna flysch assemblage and are comparable to the central segment of profile A.

MODELS

Potential Fields

Potential field modeling was undertaken to identify internal and terrane-bounding structures and to define the number and character of crustal breaks. Models were constructed using a 2½-D forward modeling system (GMSYS) that allows for nonorthogonal model strikes. Forward modeling of this type (Talwani et al., 1959; Blakely and Connard, 1989), although time consuming, can critically constrain viable structural models when combined with geologic and other geophysical data. Nonetheless, the geometry and position of some anomaly sources, such as those buried without surface exposure, present challenges to accurate potential field modeling. Because potential field models are inherently nonunique, control from other data, such as bedrock or drill-hole

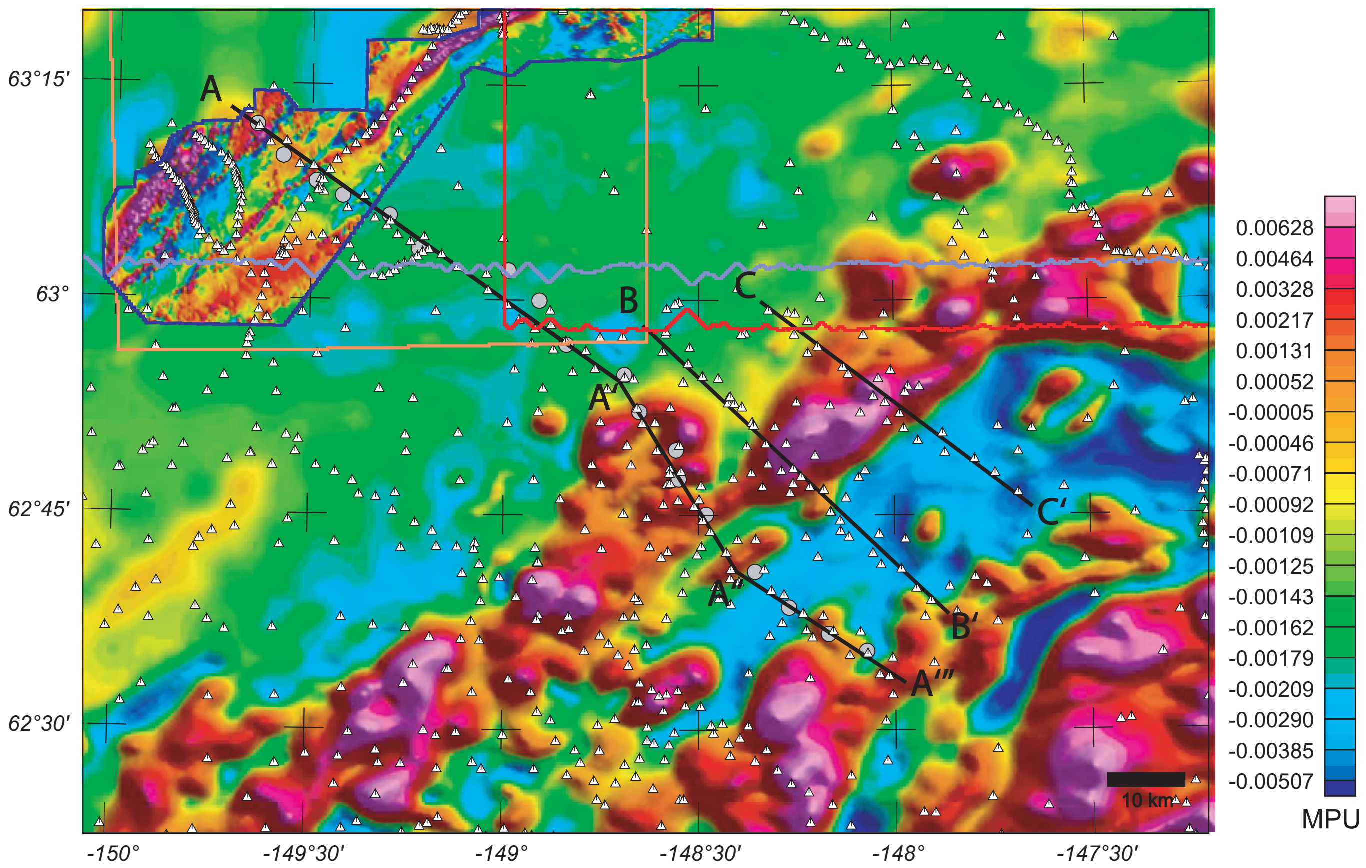

Figure 6. Residual pseudogravity map (derived from magnetic data) showing gravity (triangles) and MT (circles) stations, potential field profiles (black lines), and aeromagnetic survey boundaries (colored lines). A high-resolution survey over the Broad Pass area (blue outline) has been superimposed on top of the regional, merged survey map. Color intervals for the Broad Pass region are relative only to that survey and do not correspond to the values listed in the color table for the regional survey.

geology, seismology, or magnetotellurics, are important to constraining viable models of the subsurface.

Model bodies consist of horizontal tabular prisms or blocks aligned with their longest axes perpendicular to the profile. Their surface extents were constrained by mapped geologic units and are consistent in size, shape, and orientation with exposed features. The subsurface geometry of these outcropping model bodies was determined through a forward method to match the calculated anomalies with observed anomalies while taking into account constraints imposed by surface geology, MT results, rock property data, and geophysical data, such as maximum horizontal gradients (MHG) that helped define modeled body edges. The MHG, which tend to lie over the edges of bodies with near vertical boundaries (Grauch and Cordell, 1987; Cordell and McCafferty, 1989), highlight abrupt lateral changes in density or magnetization and are useful for estimating the extent of buried sources. Glen et al. (this volume) discuss the details of these methods and the resulting maps of domains identified at a regional scale.

Density and magnetic properties of bodies were adjusted iteratively to match observed gravity and magnetic profiles while staying within reasonable limits of values (1) for the same rock type (based on values derived from a western U.S. rock property database of over 17,000 data; Nazarova and Glen, 2004) or, when available, (2) derived from the corresponding geologic units (Sanger and Glen, 2003). No attempt, however, was made to assign remanent magnetizations to any of the model source bodies. Model bodies' magnetizations were assumed to parallel the present field direction, effectively reflecting induced magnetizations acquired in a field of 65,500 nT, 75.5° inclination, and 27° declination. Model magnetic fields were calculated on a datum that drapes topography at a nominal height of 1000 m that reflects the average elevation of the flown surveys.

Potential field models are effective at constraining the depth to the top of an anomaly's source or the location and dip of its edges. They are, however, relatively insensitive to the depth of a source's base. Hence, the models presented here characterize the shallow and deeper crust with different degrees of detail. These models portray a simplified midlevel crust (3–10 km) with fewer and less complex structures than in the shallow crust (0–3 km). Our choice of 3 km for the depth separating shallow and midcrustal levels was based on a common depth to the top of matched-filtered layers of gravity and magnetic data (at 2.5 and 3.3 km, respectively) and may imply a major structural discontinuity at that depth. Both shallow and midcrustal layers show the transition between relatively dense, magnetic crust below Wrangellia to the southeast and less dense, more weakly magnetic transitional crust beneath the flysch basins to the northwest.

All three profiles span this break between oceanic and transitional crust. In each, the structure separating the two is a deep, steeply dipping discontinuity in density and magnetic susceptibility. We interpret this structure as the crustal suture along the northern margin of Wrangellia and herein name it the Talkeetna Suture Zone. We distinguish it from any particular upper-crust faults (such as the Talkeetna thrust of Csejtey et al., 1978) but note that the deep suture clearly guided the location and development of many shallower crustal features (e.g., Susitna Lineament, Fog Lakes Lowland, Watana Creek basin, O'Neill et al., 2005).

Profile A

Profile A was defined as three segments (northwest, central, and southeast) that were modeled separately in order to position the profile near MT and gravity stations and perpendicular to the regional structural strike direction (Figs. 1 and 7). The potential field data were modeled in separate segments because the calculated magnetic anomalies are dependent on profile strike. The properties of modeled bodies in adjoining segments of the profile are matched so that model segments are consistent.

Northwest segment. The northwest segment of profile A extends from the Kahiltna flysch basin in the northwest across the Chulitna terrane and Broad Pass and into the North Talkeetna flysch basins on its southeastern end. The MT data and model do not extend as far northwest as the gravity and magnetic profiles (Fig. 7A). The geophysical character of this crustal section is of low-gravity and magnetic relief (Fig. 7A). Flysch, metamorphosed flysch, and felsic plutons derived from and intruding the flysch are largely indistinguishable in density and magnetic properties. Locally, thin magnetic mafic and ultramafic metaigneous rocks occur in the Chulitna terrane and beneath the Broad Pass graben at the northwest end of this segment. These are clearly identified in the Broad Pass aeromagnetic survey (Table 1 of Glen et al., this volume), but because they are very limited in extent, they are inconspicuous in the regional compilation.

The East Broad Pass fault, which bounds the Broad Pass graben, is a well-defined normal fault of undefined Tertiary to possibly Holocene age. It corresponds with prominent gravity and magnetic gradients and is modeled as a steeply west-dipping structure extending through the upper crust. In contrast, we have modeled the west side of the Broad Pass graben as a series of steep, likely normal faults. The Portage Creek fault, at the southeastern end of this northwest segment of profile A has a well-defined surface expression. It is modeled as a southwest-dipping structure that coincides with distinct gravity and magnetic gradients that reflect a change from continental crustal rocks to the northwest to transitional crust to the southeast.

Central segment. The central segment of profile A straddles the Talkeetna Suture Zone (Fig. 7B) and can be compared with the central portions of profiles B (Fig. 9) and C (Fig. 10) that also cross the suture zone (see Fig. 1). Gravity values increase by a factor of two from northwest to southeast across the suture zone, contrasting the relatively low density of the flysch basin and its basement rocks with higher-density oceanic crust beneath Wrangellia. The suture along profile A is less evident in the magnetic field due to a ring-like distribution of small magnetic highs northwest of the suture. These magnetic highs are inferred to result from intermediate and mafic intrusive rocks related to outcropping Eocene volcanic rocks within the Fog Lakes Lowland. Strongly magnetic rocks in the shallow subsurface produce magnetic anomalies that would mask the more subtle suture gradient contrasting weakly magnetic flysch with strongly magnetic mafic and ultramafic rocks associated with Wrangellia. A possible alternative is that the magnetic anomalies below the Fog Lakes Lowland reflect blocks of mafic and ultramafic Wrangellia-related rocks stranded northwest of the suture by postaccretionary faulting that exploited the crustal weakness along the terrane margin. The position of the deep-seated crustal discontinuity (Talkeetna Suture Zone) coincides with a broad (2–15-km-wide) zone of shallow crustal and surface structures of varying attitude and character (dextral, normal, and oblique slip) and does not correspond with any single fault or structure exposed at the surface.

Southeast segment. The southeastern segment of profile A spans the Wrangellia terrane as defined by Glen et al. (this volume) and crosses several prominent structures internal to Wrangellia. These include the Tsisi Creek and Kosina Creek faults (Fig. 7C). The geophysical character of this segment of the profile is one of generally high magnetic and gravity values that contains several prominent highs and lows and a dominantly northeast-trending fabric.

The Tsisi Creek and Kosina Creek fault zones are best modeled as a near-vertical to steeply west-dipping structure consistent with its surface expression in a long straight valley. In outcrop, it forms an east-side up structure showing a minimum of several kilometers of displacement that juxtaposes greenschist to amphibolite-grade gneiss and intermediate composition intrusives with low greenschist facies metasediments intruded by Nikolai gabbro sills.

Magnetotellurics

A two-dimensional (2-D) inverse model of the subsurface resistivity structure along profile A (Fig. 1, 7) was computed using the conjugate-gradient, nonlinear, iterative inversion algorithm of Rodi and Mackie (2001). The response to the 2-D resistivity model is computed and fit to the observed MT data. The model is adjusted and the process repeated until an appropriate RMS fit of the model response to data is reached. The quality of the model fit can be determined by the RMS and by comparing the observed data with the calculated model responses in Figure 8.

The 2D resistivity model for profile A delineates several notable features. At depth a series of low-resistivity (<50 ohm-m) units are defined: unit 1 at the northwest end of the line from stations 24 to 10; unit 2 from stations 11 to 4; and unit 3 from stations 5 to 13.

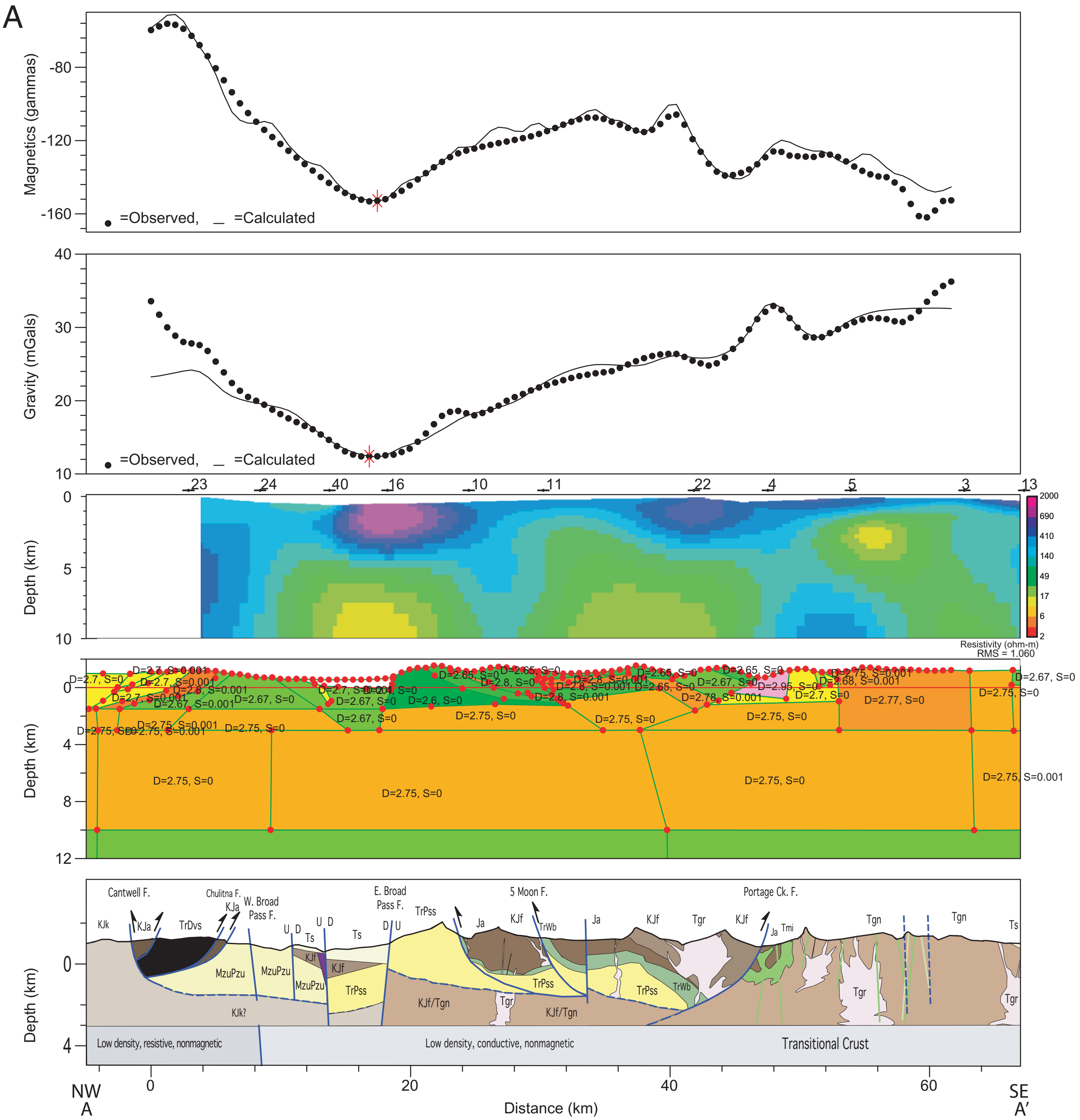

Figure 7 (*continued on the following pages*). Potential field model and MT models and geologic cross section along profile A. (A) Northwest segment A–A′. The first and second panels show observed (black circles) and modeled (solid line) anomalies for magnetic and gravity fields, respectively. The third panel shows the 2-D inverse MT resistivity model. The fourth panel shows the potential field model with individual bodies colored by density, and the fifth panel shows the geologic cross section. MT station locations and labels are indicated above the third panel. Geologic unit descriptions are given in the caption for Figure 3. Labels on the modeled bodies (in the fourth panel) indicate density (g/cc) and magnetic susceptibility (cgs) values. Tmi = Tertiary mafic intrusive rocks; KJK = Jurassic to Cretaceous Kahiltna flysch; TrDvs as in Figure 2.

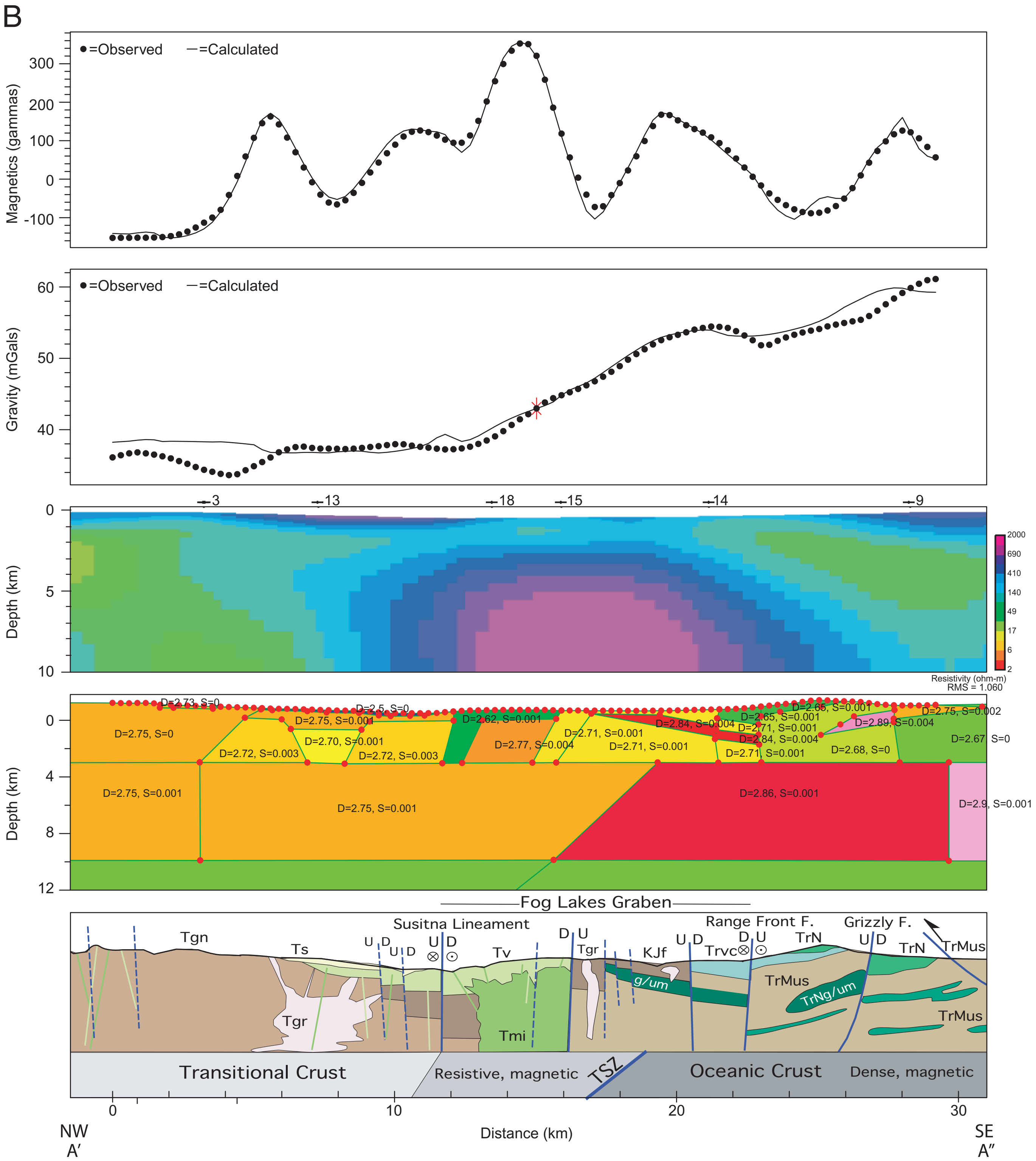

Figure 7. (*continued*). (B) Central segment A′–A″. The first and second panels show observed (black circles) and modeled (solid line) anomalies for magnetic and gravity fields, respectively. The third panel shows the 2-D inverse MT resistivity model. The fourth panel shows the potential field model with individual bodies colored by density, and the fifth panel shows the geologic cross section. MT station locations and labels are indicated above the third panel. Geologic unit descriptions are given in the caption for Figure 3. Labels on the modeled bodies (in the fourth panel) indicate density (g/cc) and magnetic susceptibility (cgs) values. TSZ = Talkeetna Suture Zone.

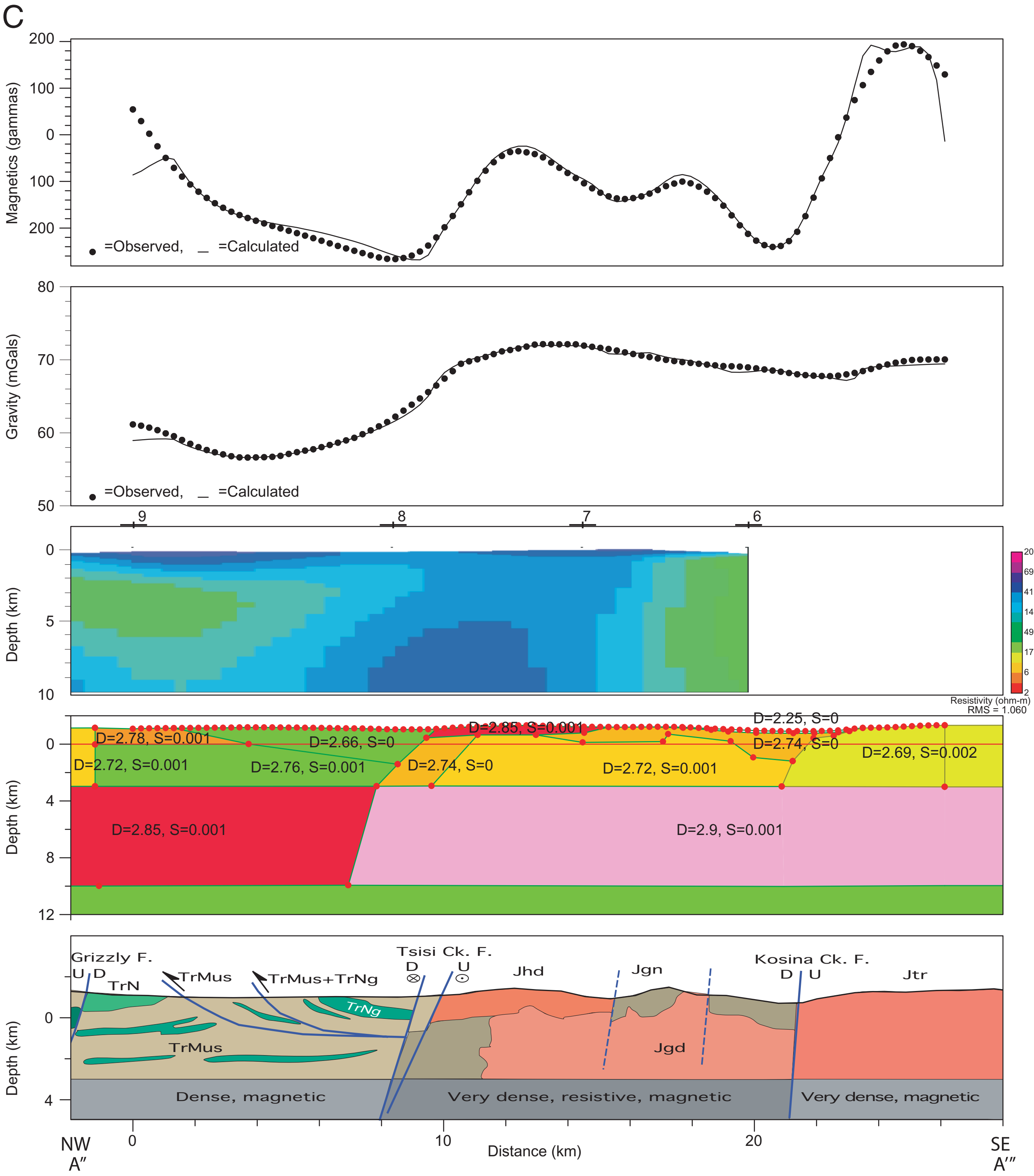

Figure 7. (*continued*). (C) Southeast segment A″–A‴. The first and second panels show observed (black circles) and modeled (solid line) anomalies for magnetic and gravity fields, respectively. The third panel shows the 2-D inverse MT resistivity model. The fourth panel shows the potential field model with individual bodies colored by density, and the fifth panel shows the geologic cross section. MT station locations and labels are indicated above the third panel. Geologic unit descriptions are given in the caption for Figure 3. Labels on the modeled bodies (in the fourth panel) indicate density (g/cc) and magnetic susceptibility (cgs) values. TSZ = Talkeetna Suture Zone.

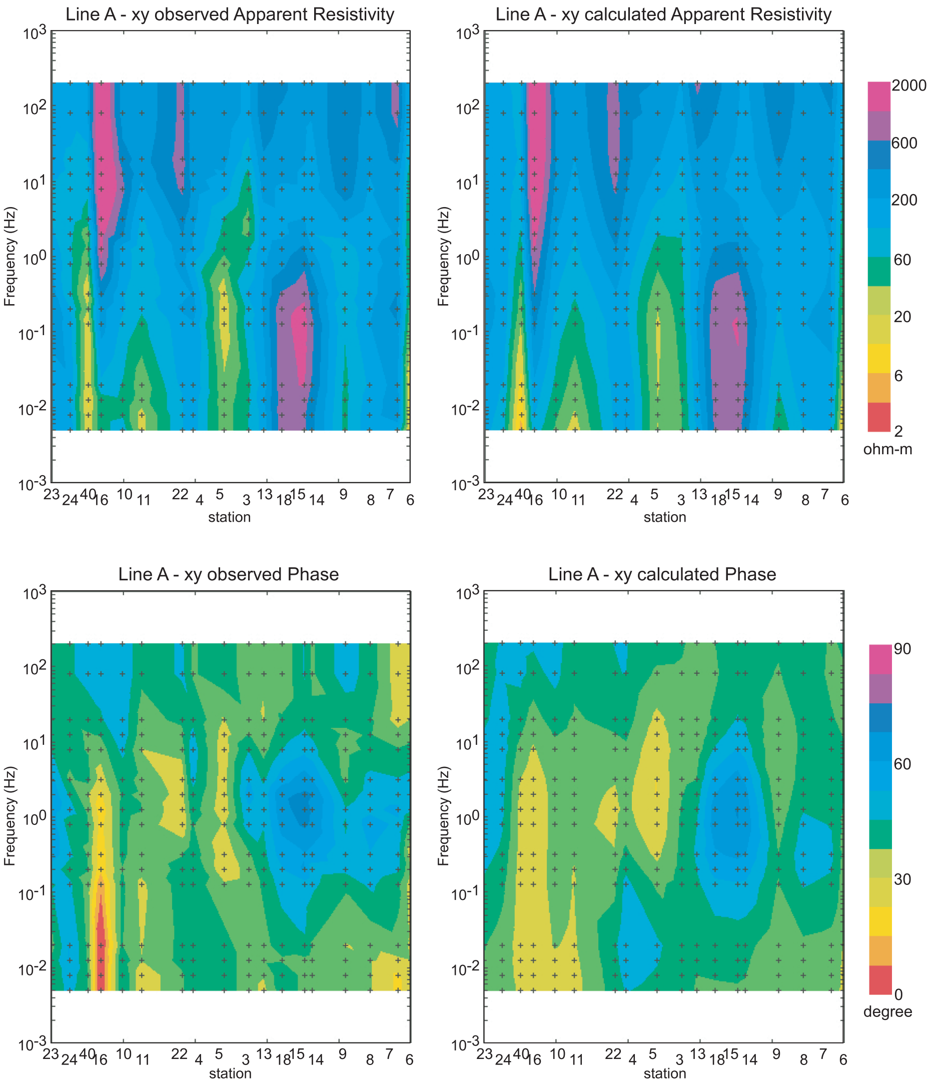

Figure 8. The observed MT data along with the calculated model responses for the 2-D inverse model shown in Figure 7.

Several resistive (>500) units are also defined: unit 4 is predominant beneath the Fog Lakes graben from stations 13 to 14, and unit 5 that extends to the surface between stations 8 and 7. Mid-value resistive (>100 ohm-m) and conductive (<100 ohm-m) units are delineated at the northwest and southeast ends of the profile, respectively. In the top ~3 km structures are more resistive. The magnetic and gravity low to the northwest corresponds to a resistivity high (~1000 ohm-m) between stations 40 and 10.

The northern Talkeetna flysch basin, defined by values predominantly <50 ohm-m, is consistent with marine deposits containing shale. Structures within the Kahiltna may reflect areas of metamorphism or the presence of Paleocene intrusions derived by melt of the flysch. Low-resistivity values at depths greater than 5 km are possibly related to crustal fluids. Mixing of lower- and higher-grade metamorphic rock releases water with soluble material resulting in a conductor. Fluids migrate up, cool, and form hydrous minerals that remove water from the metamorphic fluid and move it toward a graphitic solution (Wannamaker, 1986; Wannamaker et al., 2002). Marine sediments in the flysch contain organic matter that can be converted to conductive carbon during metamorphism. Varying levels of retrograde metamorphism could account for depletion of fluids resulting in resistive structures, whereas mobilized fluids account for those of low resistivity (Fisher et al., 2005). The deeper crustal conductors can be a result of fluids and partial melt as seen in Tibet (Wei et al., 2001; Bedrosian et al., 2001) and southern Canada (Ledo and Jones, 2001).

A highly resistive unit, characteristic of an unweathered igneous or metamorphosed rock, is evident below the Fog Lakes basin at a depth from 4 to 9 km. In the top 4 km, a body of ~100 ohm-m dips to the southeast from Station 14. A break in resistivity from roughly 1000 to 200 ohm-m to the northwest of Station 9 and a relatively low-resistivity structure at a depth greater than 5 km centered under Station 9, corresponds to a long-period potential field anomaly.

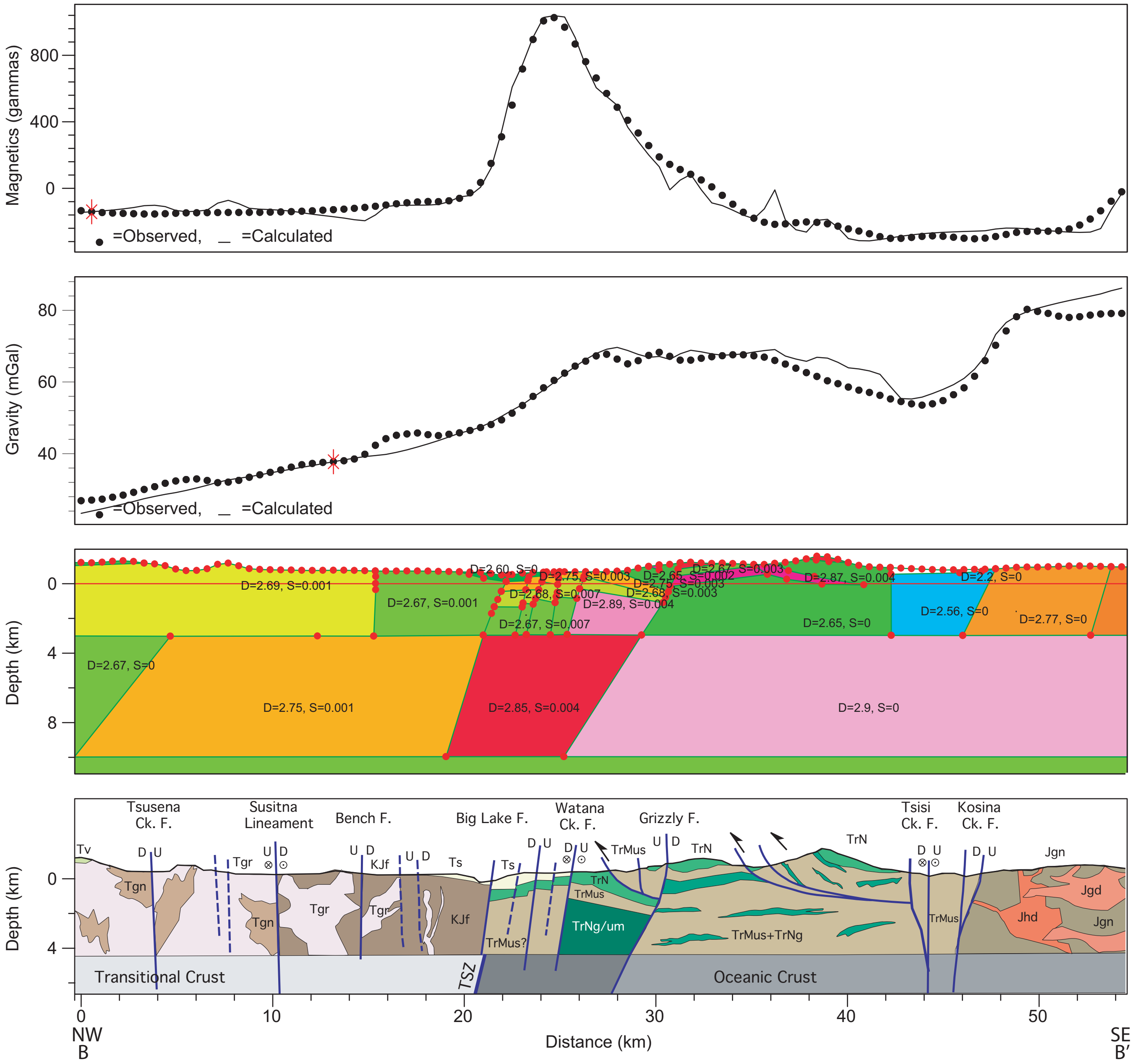

Figure 9. Potential field model along profile B. The upper two panels show observed (black circles) and modeled (solid line) anomalies for magnetic and gravity fields, respectively. The third panel shows the potential field model with individual bodies colored by density and labeled with density (g/cc) and magnetic susceptibility (cgs) values. The fourth panel shows the geologic cross section. Geologic unit descriptions are given in the caption for Figure 3. TrNg/um = Triassic Nikolai gabbro or ultramafic rocks. TSZ = Talkeetna Suture Zone.

Profile B

Profile B (~55 km long, Fig. 9), located 10 km northeast of profile A, straddles the Talkeetna Suture Zone. It spans the eastern part of the North Talkeetna flysch basin (Fig. 1) and Wrangellia and its Middle Jurassic plutons (formerly included in the Peninsular Terrane). Profile B can be compared most directly with the central portion of profile A (Fig. 7) and with profile C (Fig. 10). Gravity and magnetic values increase from northwest to southeast across the suture zone, contrasting the relatively low density and low magnetic susceptibility of the flysch basin and its basement rocks with the denser magnetic rocks of Wrangellia and its basement.

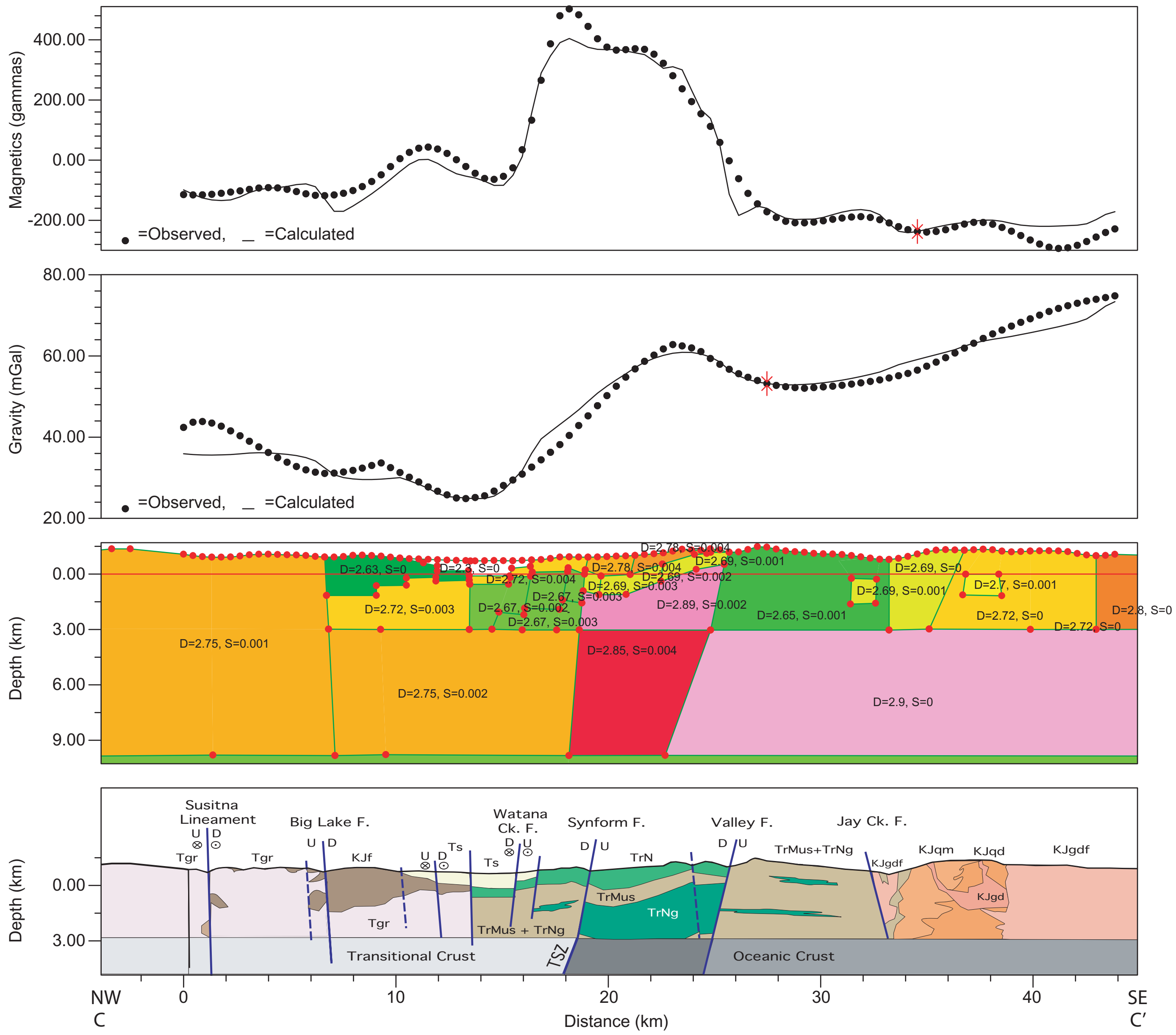

Figure 10. Potential field model along profile C. The upper two panels show observed (black circles) and modeled (solid line) anomalies for magnetic and gravity fields, respectively. The third panel shows the potential field model with individual bodies colored by density and labeled with given density (g/cc) and magnetic susceptibility (cgs) values. The fourth panel shows the geologic cross section. Tgr = Paleocene granite; KJf = flysch of the North Talkeetna basin; Ts = Oligocene to Miocene unconsolidated sediments; TrMus = sedimentary section of Wrangellia below the Nikolai Greenstone; TrN = basalts of the Nikolai Greenstone; TrNg = gabbros correlative with the Nikolai Greenstone; KJgdf = fine-grained granodiorite of indeterminate Mesozoic age; KJqm = quartz monzonite of indeterminate Mesozoic age; KJqd = quartz diorite of indeterminate Mesozoic age. TSZ = Talkeetna Suture Zone.

The main midcrustal break along profile B between the dense "oceanic" (≥2.85 g/cc) crust beneath Wrangellia and the less-dense (~2.75 g/cc) "transitional" crust is modeled as a 75° west-dipping, deep-seated (≥3 km), structure located down dip from the Big Lake fault at the surface. Steep (>55°) west-dipping subsidiary midcrustal breaks were also modeled within Wrangellia 6–8 km southeast of the main suture zone, below imbricated sheets of Wrangellia stratigraphy, and within the transitional crust ~15 km west of the Talkeetna Suture Zone, below gneiss, schist, and plutons derived from metamorphosed flysch.

A large volume of high-density, highly magnetic material is required to account for the potential field values beneath the eastern part of the Fog Lakes lowland (in the vicinity of Watana Creek and Big Lake, Fig. 9). We have modeled this material as a block (<2 km depth) of mafic and ultramafic rocks related to the Nikolai Greenstone and outboard of the previously mapped westernmost edge of the Wrangellia terrane ("Talkeetna Thrust" of Csejtey et al., 1978).

The southeastern end of profile B crosses the Tsisi Creek and Kosina Creek faults—two prominent northeast-striking structures with east-side up motion. The Tsisi Creek fault is aligned with prominent gravity and magnetic gradients and marks the northwest edge of a band of gravity and magnetic highs that may represent mafic and ultramafic rocks correlative with the Nikolai Greenstone. It is modeled as a vertical fault in the near surface (<3 km) that intersects the Kosina Creek fault just north of profile B.

The Kosina Creek fault is modeled as a steeply ($\sim65°$) west-dipping structure in the near surface (<3 km) that juxtaposes Wrangellia sedimentary and gabbroic rocks (2.65 g/cc) to the west with lower density (2.56 g/cc) granodioritic and hornblende dioritic rocks that intruded the Wrangellia section in middle Jurassic time (ca. 165 Ma).

Profile C

Profile C (~45 km long, Fig. 10) lies roughly 15 km northeast of profile B and straddles the Talkeetna Suture Zone. It spans the eastern parts of the North Talkeetna basin flysch and the Wrangellia terrane and is comparable to profile B and the central segment of profile A (Fig. 1). Gravity and magnetic values increase dramatically from northwest to southeast across the suture zone, reflecting relatively low density and magnetic susceptibility of rocks in and below the flysch basin as opposed to dense magnetic rocks beneath Wrangellia. The break between "oceanic" and less-dense "transitional" crust is modeled along profile C as a steep deep-seated, west-dipping structure located below the range front east of Watana Creek.

The northwest part of profile C exposes flysch of the North Talkeetna basin, Paleocene granites that intrude them, and Paleocene gneisses derived from them (Fig. 10). These three rock units are very similar in geophysical expression, which is consistent with metamorphorism and melting of the flysch to produce the plutons. Miocene to Oligocene unconsolidated sediments fill the Watana Creek graben that occurs just outboard of the Talkeetna Suture Zone midcrustal break. Relatively magnetic and dense Nikolai basalt and its basement rocks are modeled below the Watana Creek graben, again extending outboard of the deeper Talkeetna Suture Zone structure. The southeastern portion of this profile crosses a steep, up-to-the-east fault (the Jay Creek fault), which, like the Tsisi Creek and Kosina Creek faults to the south, juxtaposes Mesozoic intrusive rocks against sedimentary, volcanic, and gabbroic rocks of the Wrangellia terrane.

DISCUSSION

Major Crustal Types and Terranes

Terrane affiliations in and near the Talkeetna Mountains transect study area have been redefined by Glen et al. (this volume). These modifications include expansion of the Wrangellia terrane to the southeast and a consequent restriction of the Peninsular terrane. The currently identified Wrangellia-Peninsular boundary in the Talkeetna Mountains coincides with the Busch Creek fault. Glen et al. (this volume) have also subdivided the formerly uniform Kahiltna overlap assemblage into a Kahiltna block to the northwest and a North Talkeetna block occurring southeast of Broad Pass, which includes the former Susitna and Broad Pass terranes. This subdivision suggests that separate, and distinct crustal blocks underlie the two distinct and separately sourced flysch basins defined by sedimentologic and provenance data (Eastham and Ridgway, 2002; Ridgway et al., this volume). Both flysch basins, as well as the Chulitna and West Fork terranes, rest on lower crust of transitional composition and isotopic character (Arth, 1994; Glen et al., this volume).

Using these newly modified terrane boundaries, the Talkeetna Mountains transect primarily spans the North Talkeetna overlap assemblage and the Wrangellia terrane, a small part of the Peninsular terrane, and the West Fork and Chulitna terranes that lie between the two flysch basins. The Wrangellia terrane within the Talkeetna Mountains contains a significantly different pre-Nikolai stratigraphy than that known from the type section in the Wrangell Mountains, from southeast Alaska, or within the Canadian Cordillera (e.g., Werdon et al., 2001; Schmidt et al., 2003). Wrangellia within the transect area is characterized by numerous gabbroic sills interpreted as feeders to the Nikolai Greenstone that intrude fine-grained quartz-rich sedimentary rocks, volcanic rocks, and shallow-water limestones of Mississippian to Middle Triassic age. It was later intruded by a Middle Jurassic (ca. 160 Ma) plutonic complex (comprised of hornblende diorite, granodiorite-tonalite, and a weakly magnetic trondjhemite-tronalite suite) that metamorphosed the Nikolai Greenstone. The reinterpreted Wrangellia-Peninsular boundary lies along the southeastern margin of the mapped trondjhemite-tonalite body, which is characterized by a distinctive magnetic low (Glen et al., this volume).

Shallow versus Deep Crust

On a regional scale, both the shallow (0–3 km) and midlevel (>3 km) crust indicate a prominent structural break coincident with the Talkeetna Suture Zone. The position of this break is determined from gradients in the potential field data and a strong contrast in electrical resistivity in the MT model. Both potential field and MT data indicate the feature is a steeply dipping deep-crustal structure. A slight offset between the steepest gravity and magnetic gradients suggests that the structure may be offset to the northwest between shallow and deeper crust.

This offset may occur because (1) the magnetic profile is complicated by magnetic rock bodies immediately east of the suture; (2) younger structures in the shallow crust formed over a much broader zone than the deep suture, and no one structure at the surface is continuous with the deep crustal break; or (3) the upper and lower crust were decoupled along a subhorizontal detachment. A horizontal discontinuity also explains the close correspondence between the matched-filtered depth solutions obtained for gravity and magnetic data, which indicate a discrete boundary (Glen et al., this volume) and is suggested by the MT (Fig. 7A) data that show abrupt subhorizontal transitions in the resistivity structure of the crust at a depth of 2–4 km below the surface.

Structures

Much of the prominent geologic fabric within the Talkeetna Mountains is northeast-trending, including major terrane sutures, the strike of geologic units within Wrangellia, the orientation of Late Cretaceous and early Tertiary faults, and structures whose tectonic significance and age are not yet known. The character of structures occurring within this collisional zone is highly variable. Mapped structures include steep reverse faults, near-vertical faults with both normal and reverse offset, an unknown component of right-lateral strike-slip displacement, and less common low-angle thrust faults, suggesting a wide range of tectonic settings from late Mesozoic time to the present. Absent, however, are Alpine-style nappes that were once considered to be the dominant character of northeast-trending structures aligned with the Talkeetna Suture Zone.

Areas of extension are indicated by grabens or half-grabens with Tertiary terrestrial clastic fill, such as the Watana Creek and Broad Pass basins. The Fog Lakes lowland, is a rhombohedral zone ~12 km across at its widest point. It is bounded on the west by the Susitna lineament, to the southeast by a series of range-front normal faults, on the northeast by the Watana Creek fault, and is centered above the Talkeetna Suture Zone. It formed as a transtensional basin along a zone of dextral shear (O'Neill et al., 2005) and has structural components that reflect Eocene, Oligocene, and Miocene activity.

The amount of strike-slip motion on any of the near-vertical structures is unknown. Most of these faults likely accommodate a combination of transcurrent and compressional stresses and result in combined relative uplift, translation, and rotation of adjacent crustal blocks. Northeast-trending structures between the Talkeetna Suture Zone and Broad Pass accommodate vertical uplift as well as unknown amounts of strike-slip motion. Other structures southeast of Broad Pass are southeast-vergent reverse faults with moderate dip angles. Reverse faults with moderate dip angles in the Honolulu Block repeat Norian or younger basalt and flysch of latest Triassic(?) to early Cretaceous(?) age and localize the intrusion of small plugs that probably fed Eocene volcanic rocks. In the Meridian-Portage Creek area, relatively shallow-dipping (<40°) reverse faults offset both Paleocene granites and their Cretaceous to Permian(?) wall rocks. West-directed shallow-angle thrusting in Wrangellia, on the other hand, is internal to the terrane, generally of limited extent, and likely of post-Triassic, pre-Oligocene age. Steep, east-side up structures such as the Tsisi Creek and Kosina Creek faults, which uplift the Kosina Creek batholith, are post–Middle Jurassic in age, and the uplift of mid-Jurassic plutons appears to have been early, fast, and near vertical.

Many structures in the study area are complex, forming series of related features, such as anastomosing and flower-like fault sets and conjugate fracture patterns. The Susitna lineament, although appearing continuous on satellite photography, is comprised of a series of enechelon segments, and the Tsisi Creek and Kosina Creek faults consist of several discrete surface fault strands. Aligned offsets of small drainages suggest the presence of multiple structures parallel to range-front faults (e.g., bounding the west sides of Grizzly Ridge and Broad Pass).

Tsisi Creek Fault

The Tsisi Creek fault (Fig. 1) is a near vertical northeast-trending fault with up-to-the-east motion and an uncertain component of dextral slip. It intersects the Kosina Creek fault just north of profile B. Offset shearing and deformation of Middle Jurassic (ca. 165 Ma) intrusive rocks indicates that the Tsisi Creek and Kosina Creek faults were active after intrusion during cooling of the plutons (ca. 150 Ma). The Tsisi Creek fault forms a boundary to a discrete belt of prominent gravity and magnetic highs that lie within the Wrangellia terrane in the central Talkeetna Mountains (see also Glen et al., this volume). These presumed mafic and ultramafic igneous rocks (Glen et al., this volume) may be blocks of oceanic crust aligned along this major intraterrane shear zone.

Talkeetna Suture Zone

The most prominent geophysical feature in the Talkeetna Mountains region coincides with the Talkeetna Suture Zone, a major linear density and magnetization contrast present along all three transect profiles. Measured rock densities of samples taken southeast of the suture zone are generally higher than to the northwest (Glen et al., this volume) indicating that some, but not the majority, of this gravity anomaly arises from rocks in the shallow crust. Forward and inverse potential field models demonstrate that a strong contrast in density and magnetic susceptibility must exist in the deep crust to account for the observed anomalies, indicating that the Talkeetna Suture Zone is a deep-seated crustal discontinuity. Matched filtered maps of the gravity and magnetic fields (Glen et al., this volume), which are used to separate anomalies arising from shallow, intermediate, and deep crustal sources, show that the Talkeetna suture forms a profound discontinuity at all depths—the lowermost matched-filter layer extending to 18 km and 9 km for gravity and magnetic data, respectively. This feature most likely reflects the contrasting character of dense oceanic lower crust on which Wrangellia formed with less dense, transitional-to-continental crust under the flysch basin.

Forward and inverse 2½-D models reveal that the discontinuity in the vicinity of profile A has a steep northwest dip. This agrees with potential field model dip estimates from a segment of the fault a few tens of kilometers to the southwest of the transect (Griscom, 1979) that suggest the fault dips to the northwest. This is also consistent with observations in the Talkeetna B5 quadrangle, where the contact between metamorphosed flysch and Wrangellia rocks dips 75°W with small-scale structures suggesting local reverse motion (J.M. Schmidt, 1999, field observations). However, model estimates of dip along the Talkeetna suture immediately north and south of the Talkeetna Mountains transect suggest that the structure dips steeply to the southeast. This may indicate that either the orientation of the deep fault varies along the strike or that separate fault segments with slightly different dips bound each of the modeled anomalies, as might occur within a complex suture. In any case, the Talkeetna Suture Zone represents a steeply dipping major crustal boundary between oceanic and less-dense transitional crust that extends through the shallow and deep (10–15 km) crust.

Reactivation

Throughout the study area, structures of different age and character commonly occur together, and in some cases individual fault zones reflect repeated movement. Surface features such as structures of the Watana Creek basin, Fog Lakes Lowland, and Broad Pass basin often occur over deep crustal breaks. Although the structures may occur near one another, they are not necessarily coincident. The Fog Lakes Lowland, for example, is a 2–12-km-wide zone of complex structures that overlie the singular, deep-seated Talkeetna Suture Zone.

Profound deep-crustal discontinuities are natural weaknesses that are easily reactivated and may guide shallow crustal faulting. This is echoed by recent shallow seismic activity in the northern Talkeetna Mountains localized along some of the same northeast-striking structures that are inferred to have resulted from Tertiary or earlier tectonics (O'Neill et al., 2005). The coincidence of young, shallow features with deep, presumably old structures suggests an underlying control on recent tectonics by preexisting crustal fabric. Although the age of formation of the Talkeetna Suture Zone is unknown, it offsets Middle Triassic rocks (i.e., the age of Nikolai Greenstone rocks) but could be much older if it represents an inherited suture between crustal fragments over which the Nikolai flood basalt province was subsequently extruded.

Despite the temporal uncertainty and structural complexity of the Talkeetna Suture Zone terrane boundary, it forms a relatively smooth northeast-trending path through the Talkeetna Mountains. Prior to collision, the shape of the approaching Wrangellia terrane mass was probably far more complex. Accretion and subsequent reactivation of structures has likely narrowed and straightened the suture. Like many collision margins (e.g., Anatolia, or the Coast Megalineament; Brew, 2001) the original complex suture is overprinted by later structures that straighten and simplify the structure regionally.

On a local scale, this process isolates fragments of crust from each side of the original suture and leaves them stranded to either side of the younger, straighter structure. An example of this is where we have modeled blocks of strongly magnetic Nikolai related rocks below the Fog Lakes Lowland, outboard of the farthest known surface exposures of Wrangellia.

CONCLUSIONS

The MT and potential field models are used to constrain the geometry of major known faults and structures in south-central Alaska. We find that the single most prominent structure in the Talkeetna Mountains is the Talkeetna Suture Zone—a first-order crustal discontinuity that forms a deep, steeply-dipping crustal break. No direct age control exists for this deep structure, but it coincides with historic to accretion age features and is inferred to represent the suture between the Wrangellia terrane and continental North America.

In general, structures in the study area reflect a long and complex history of activity that has likely overprinted evidence of earlier tectonic history. Preexisting structures form crustal weaknesses that can localize later faulting and accommodate subsequent tectonic activity.

The general correspondence of young, shallow faulting to an older, deep-seated suture indicates that Tertiary to Recent faulting in the Talkeetna Mountains is guided partly by the inherent crustal weakness along the suture. On a regional scale, subsequent faulting tends to smooth out any irregularities along the terrane margin, whereas on a local scale, reactivation of the suture may result in blocks of crust being stranded from its source terrane.

ACKNOWLEDGMENTS

We are grateful to Warren Nokleberg and Brian Rodriguez, who provided helpful reviews. We thank Dolores Kulik (1999), Jay Sampson and Peter Oswald (2000–2001), and Brian Meigs (2002) for their assistance in collecting gravity and MT data. Gary Brogdon, Maritime Helicopters (1999); Cliff Adkins, Kenai Air (2000), Bill Merkley, Transalaska Helicopters (2000–2001), and Dave Beard, Prism Helicopters (2002), provided indispensable aerial support. Nora Shew (USGS) and Bob Rogers (Kelly Services) helped with preparation of figures. We thank Ron Cole, Skip Cunningham, Kevin Eastham, Brian Hampton, Steve Nelson, Ken Ridgway, and Jim Riehle for their contributions to the transect geologic map. The MT equipment used in the 2002 field season was provided by funds from the Electromagnetic Studies of the Continents Consortium of the National Science Foundation.

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MANUSCRIPT ACCEPTED BY THE SOCIETY 31 JANUARY 2007