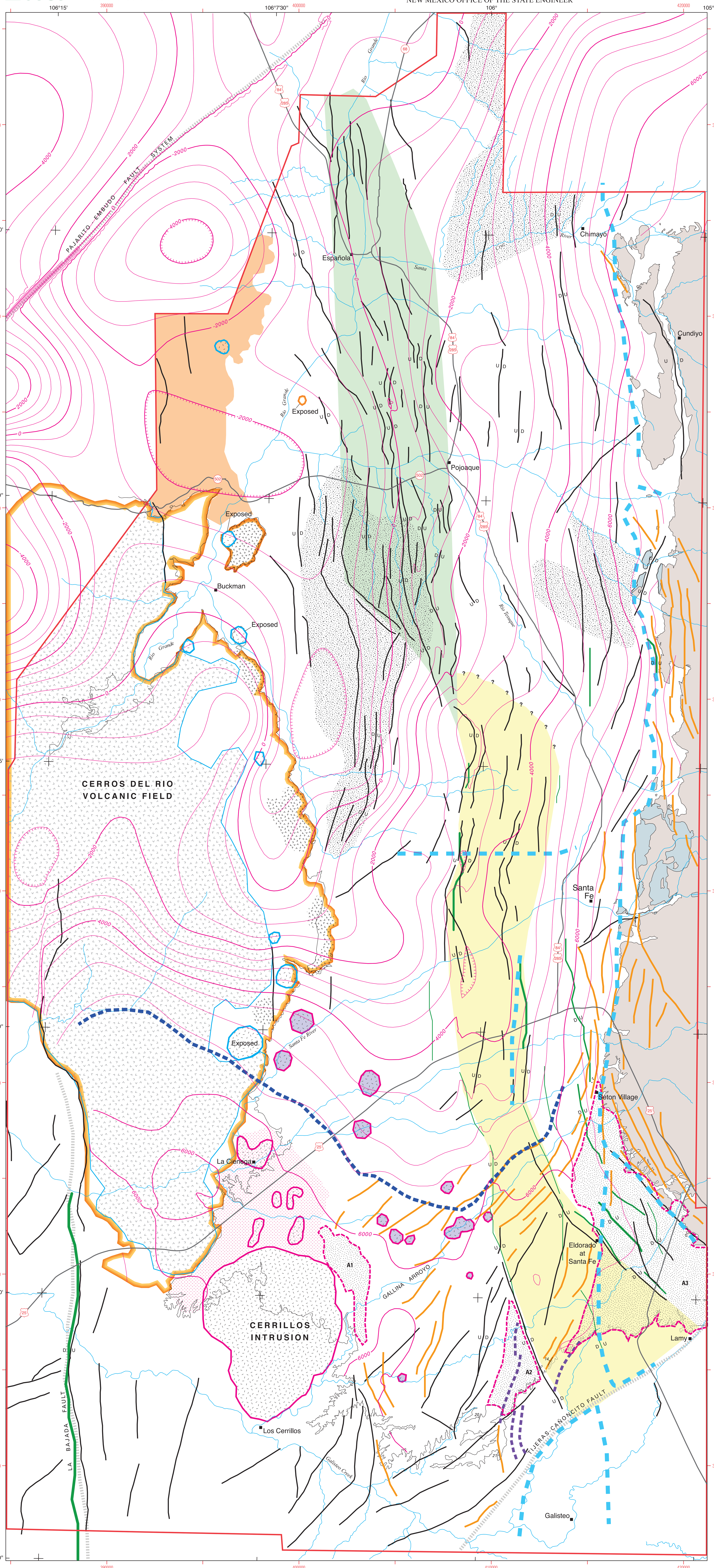
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NEW MEXICO OFFICE OF THE STATE ENGINEER

PROFESSIONAL PAPER 1761
PLATE 1



Base from U.S. Geological Survey
Universal Transverse Mercator projection
1927 North American datum
5,000-meter Universal Transverse
Mercator grid ticks, zone 13, shown in red

TRUE NORTH
MAGNETIC NORTH
9½°
APPROXIMATE MEAN
DECLINATION, 2008

SCALE 1:100 000
1 0 1 2 3 4 5 6 7 8 MILES
1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

NEW MEXICO
MAP LOCATION

EXPLANATION

Aeromagnetic data area—Showing limit of high-resolution data coverage

INTERPRETED ELEMENTS OF BASIN FILL

Magnetically defined extent of Cerros del Rio volcanic field—Limit of basalt and andesite (Pleistocene-Pliocene) at the surface and just below the surface. Basalt inferred to underlie sediments where these limits extend beyond mapped volcanic field

Thin basalt—Basalt estimated as <50 m (160 ft) thick within the Cerros del Rio volcanic field. Interpreted only within aeromagnetic data area

Area of numerous vents and intrusions—Vents and intrusions are too numerous to interpret individually within the Cerros del Rio volcanic field. Interpreted only within aeromagnetic data area

Interpreted intrusions or volcanic vents—Likely associated with the Cerros del Rio volcanic field. Outline represents general limit of the intrusive body at depth. Exposed vents are labeled "exposed"

Area underlain by magnetic Puye Formation of the Santa Fe Group (Pliocene-Pleistocene)— Inferred from aeromagnetic patterns. Interpreted only within aeromagnetic data area

Area underlain by magnetic sediments—Inferred from aeromagnetic patterns. Includes Santa Fe Group and stream terrace gravels. Magnetic sediments may indicate coarse grain size. In some areas, the magnetic sediments may indicate a relatively large fraction of magnetic lithic content, such as volcanic detritus. Interpreted only within aeromagnetic data area

— 2000 — **Elevation of the modeled base of Santa Fe Group sediments (Oligocene-Pleistocene)**— From the three-dimensional integrated model. Contour interval equals 500 feet; datum is sea level. Hachured in areas of closed lows. Model applies only to basin-fill areas. Digital grid of model surface is available as part of this publication

INTERPRETED ELEMENTS OF BASIN FLOOR

A1 **Area where Tertiary older volcanic rocks are largely absent**—Inferred from aeromagnetic patterns. Tertiary older volcanic rocks include the mainly volcaniclastic Espinaso Formation (late Eocene and Oligocene) and Cieneguilla volcanic complex (Oligocene) and where absent, Santa Fe Group sediments lie directly on older sedimentary units. Boundaries of the areas coincide with inferred erosional edges of the volcanic rocks unless otherwise indicated. See plate 2, this publication

A1—Ancha and Tesuque Formations of the Santa Fe Group likely overlie Galisteo Formation (Eocene)

A2—Ancha Formation of the Santa Fe Group likely overlies Galisteo Formation (Eocene)

A3—Ancha and Tesuque Formations of the Santa Fe Group likely overlie Galisteo Formation (Eocene) in the southwest corner and, from west to east, Mesozoic sedimentary rocks, Paleozoic sedimentary rocks, and Precambrian basement

Buried volcanic vents—Inferred to be associated with the Espinaso Formation (late Eocene and Oligocene). Negative aeromagnetic anomalies indicate a strong, reverse-polarity remanent magnetization

Lateral limit of intrusions or volcanic vents—Limits interpreted to define the extents of the bulk volume of intrusive bodies related to the Cerrillos intrusive complex (Eocene and Oligocene) at depth

Area difficult to interpret—Geologic units with similar magnetic properties likely overlie each other where concealed; other information is not available

Magnetic unit within Galisteo Formation—Inferred from aeromagnetic patterns in areas mapped as Eocene Galisteo Formation (Lisenbee, 1999) and extrapolated to areas covered by Santa Fe Group sediments

Major intrabasement contrast in magnetic properties—Interpreted as a major contrast in lithology, such as a pre-rift intrusive contact or fault, or a difference in regional basement fabric

INTERPRETED STRUCTURE

Agua Fria fault system—Characterized by west-tilted and chaotic blocks bounded by east-down normal faults. Primarily recognized in the southern area below undeformed Plio-Pleistocene Santa Fe Group sediments from multiple geophysical data sets. The system includes exposed faults on the south and along the Santa Fe River. Inferred to represent deformation that predates the Plio-Pleistocene sediments. Northern extent is queried because it is uncertain

U/D **Fault location interpreted from magnetic data**—Magnetically interpreted near-surface fault offsetting basin-fill sediments (Grauch and Hudson, 2007). Some faults may affect basement rocks as well, but the aeromagnetic expression comes mainly from juxtaposition of shallow strata that have contrasting bulk magnetic properties. U and D labels indicate sense of throw in localities where independent information can be directly compared with the interpreted faults

U/D **Fault location interpreted from gravity data**—Inferred from the horizontal gradient magnitude (HGM) of gravity data. Four different line weights, from thin to thick, indicate small to large HGM values. The HGM relative value may indicate large fault throw that juxtaposes geologic units with large contrasts in density, such as sediments against consolidated rocks or sedimentary rocks against crystalline rocks. See table 2, this publication, for density measurements in this area. U and D labels indicate sense of throw in localities where independent information can be directly compared with the interpreted faults

Magnetic lineament of undetermined origin—Line is drawn along the crest of linear anomaly that may be associated with a fault, a geologic contact unrelated to faulting, or a linear geologic feature such as a paleovalley (such as those near the Rancho Viejo hinge zone) or regional metamorphic fabric (such as those in areas of exposed Precambrian basement)

Rancho Viejo hinge zone—Zone where three-dimensional model shows that the basin floor abruptly descends to the north, accompanied by a pronounced thickening of overlying Santa Fe Group sediments and a contrast in aeromagnetic patterns (fig. 23*A*, this publication)

GEOLOGIC FEATURES

Surface exposure of Paleozoic limestones—Generalized from mapped surface geology (Read and others, 2004)

Surface exposure of Precambrian basement—Generalized from mapped surface geology (fig. 3, this publication)

Barrancos fault system—Zone of west-down and east-down normal faults associated with the west-dipping Barrancos monocline, first recognized by Kelley (1978) and Koning (2002). Expressed as abundant faults mapped geologically (fig. 3, this publication) and inferred from magnetic interpretation (indicated on this plate). The monocline is represented in 2D geophysical and 3D integrated models as steep, west-dipping slopes on basin floor. Its southern extent is poorly constrained

Geologic contact of Santa Fe Group sediments—Generalized from mapped surface geology (fig. 3, this publication)

Mapped fault zones—For comparison with geophysical interpretations and modeling

La Bajada fault—Generalized trace of mapped fault for comparison with inferred faults from magnetic and gravity data. Commonly considered the southwest boundary of the Española Basin (Minor, 2006)

Pajarito-Embudo fault system—Represents the master bounding fault to the west-dipping half-graben in the Española Basin. Generalized from gradients in the gravity data, the fault trace shown is only a simplified, regional representation of mapped faults in the area

Tijeras-Cañoncito fault—Main trace of the strike-slip fault system for comparison with areas outlined by inferred major intra-basement contrasts in magnetic properties. Two north-south elongated areas that surround basement-related aeromagnetic highs on either side of the fault (fig. 15, this publication) appear to show ~5 km (3 mi) of right-lateral offset

14 **Strike and dip of Espinaso Formation**—Measured on exposed rocks near the southern basin margin by Lisenbee (1999)

REFERENCES CITED

Grauch, V.J.S., and Bankey, Viki, 2003, Aeromagnetic interpretations for understanding the hydrogeologic framework of the southern Española Basin, New Mexico: U.S. Geological Survey Open-File Report 03–124, 44 p., *http://pubs.usgs.gov/of/2003/ofr-03–124*

Grauch, V.J.S., and Hudson, M.R., 2007, Guides to understanding the aeromagnetic expression of faults in sedimentary basins—Lessons learned from the central Rio Grande Rift, New Mexico: Geosphere, v. 3, no. 6, p. 596–623. doi: 10.1130/GES00128.1

Grauch, V.J.S., Phillips, J.D., Koning, D.J., Johnson, P.S., and Bankey, Viki, 2009, Geophysical interpretations of the southern Española Basin, New Mexico, that contribute to understanding its hydrogeologic framework: U.S. Geological Survey Professional Paper 1761, 88 p.

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Koning, D.J., 2005 (orig. publ. 2002), Preliminary geologic map of the Española 7.5-minute quadrangle, Rio Arriba and Santa Fe counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map OF–GM–54, scale 1:24,000.

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Minor, S.A., ed., 2006, The Cerrillos uplift, the La Bajada constriction, and hydrogeologic framework of the Santo Domingo basin, Rio Grande rift, New Mexico: U.S. Geological Survey Professional Paper 1720, 189 p., 6 plates.

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Read, A.S., Koning, D.J., and Johnson, P.S., 2005 (orig. publ. 2004), Generalized geologic map of the southern Española Basin, Santa Fe County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Report 481, scale 1:50,000, CD-ROM.

Geophysical interpretations are depicted as lines, polygons, patterns, and contours representing a three-dimensional model surface. The interpretations were derived primarily by V.J.S. Grauch during 2007–2008 on the basis of qualitative interpretation, quantitative data analysis, and two- and three-dimensional modeling of high-resolution aeromagnetic and regional gravity data that incorporate a variety of independent constraints. The interpretations build on earlier work by Grauch and Bankey (2003) and Phillips and Grauch (2004) but contain considerable new information and modifications to earlier models. The updated geophysical data, methods, approach, sources of independent constraints, caveats, models, and evaluations of interpretations are described in detail in the text of this publication (Grauch and others, 2009).

V.J.S. Grauch digitally merged high-resolution aeromagnetic data from surveys flown during 1997–2005 (section "Aeromagnetic Data"). She is also responsible for analysis, interpretation, and modeling that is not attributed otherwise, as follows.

J.D. Phillips designed and modified magnetic depth-estimation techniques specifically for this study (section "Magnetic Depth Estimation" and appendix 3). He also supplied computer programs and collaborated on general data analysis and magnetic interpretation.

D.J. Koning provided extensive guidance on geologic information, much of which is derived from his own mapping (sections "Geologic Setting" and "Other Data").

P.S. Johnson provided locations, data, and assistance on interpreted lithology in wells that she and D.J. Koning compiled (section "Other Data" and appendixes 1 and 2).

Viki Bankey compiled and rectified inconsistencies in gravity data available as of 2006 (section "Gravity Data") and helped construct two-dimensional geophysical models (section "Profile Models").

Additional independent constraints are in large part from unpublished sources (most recently from 2008) that are described in the text; they include physical-property measurements (section "Physical Properties", table 2, and fig. 4) and other types of geophysical interpretations and well data (section "Other Data" and appendix 4).

COMPOSITE OF SELECTED GEOPHYSICAL INTERPRETATIONS FOR THE SOUTHERN ESPAÑOLA BASIN, NEW MEXICO

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