# Geologic Map of the Grants SE Quadrangle, Cibola County, New Mexico

By

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**New Mexico Bureau of Geology and Mineral Resources**
*Open-file Digital Geologic Map OF-GM 241*

Scale 1:24,000

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Grants SE unit descriptions
CT Cikoski

Note: Soil descriptions after Birkeland (1999), colors after Munsell Color (1994), and all proportions are visual estimates.

**Artificial units**

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| af | Artificial fill. Compacted gravel, sand, and mud underlying roads, railroads, and water tanks. Up to 5 m thick. |

**Colluvial and slopewash units**

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| Qsw | Slopewash. Sandy silt and silty sand accumulating in depressions in landslide areas. Likely up to 2 m thick. |
| Qdf | Deflationary pits. Gray to brown (7.5YR 7/2 and 5YR 4/2 measured), generally well-laminated silt and lesser clay with 5-15% fine sand, subangular to subrounded, accumulating in depressions. Likely up to 2 m thick. |
| Qc | Colluvium. Gravels, sands, and silts transported by mass wasting and thin water flow. Likely up to 2 m thick. |
| Qls | Landslides. Slumps, slides, debris-flow deposits, and associated fine-grained material underlying hummocky terrain along slopes below basalt-capped mesas. |

**Eolian units**

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| Qes | Eolian sand. Silty fine sand and fine sandy silt forming sand sheets and low dunes. Pale brown colors typical, with colors of 7.5YR 7/3 to 7/6 and N 9 measured. Little evidence of soil development. Likely up to 2 m thick. |
| Qes/Qb_ | Eolian sand over basalt. Hybrid unit that locates areas of basalt flows largely buried by thin (0-1 m thick) eolian sand cover. |
| Qesd | Dune sand. Clean to silty fine sand and fine sandy silt forming dune forms of variable development and sandsheets with mounded microrelief. Variably vegetated, with the more vegetated dunes displaying weak soil development such as Stage I gypsum accumulation. As much as 5 m thick. |
| Qae | Alluvial and eolian sand, undivided. Silty sand and sandy silt transported by wind, slopewash, and confined water flow. Variably vegetated, typically does not exhibit signs of soil development. <1/2 to 2 m thick. |

**Alluvial units**

*Rio San Jose alluvium*

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| Qaj | Alluvium associated with the Rio San Jose, undivided. Sand and silt with lesser gravel and rare clays. Typically further subdivided into age units. |
| Qajh | Historic alluvium associated with the Rio San Jose. Alluvium found along the current floodplain of the Rio San Jose that does not exhibit signs of soil development. Deposits are typically poorly to moderately sorted angular to rounded silt/sand grains and fine pebbles. Likely up to 1 m thick. |

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| Qajhf | Historic alluvium associated with thin alluvial fans from the termini of gullies and channels along the Rio San Jose floodplain. Likely up to 1 m thick. |
| Qajy | Younger alluvium associated with the Rio San Jose. Alluvium underlying terrace treads up to 2 m above the active channel, with typical soil development including a weak reddened Bw horizon and up to Stage I Bk development. Colors of 10YR 5/4 to 5/6, 7.5YR 5/3 to 5/4, and locally 5YR 4/4 and 7/4, measured. Likely not more than 3 m thick. |
| Qajo | Thin deposits of sand and gravel associated with the Rio San Jose at relatively high elevations along the active channel. Largely only identifiable by the presence of sparse granitic and siliceous pebbles that do not occur in underlying strata. No signs of soil development observed. 0-1 m thick. |

*Las Ventanas Ridge and Horace Mesa alluvium*

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| Qaf | Alluvial fan material from Mezosoic-cored highlands, undivided. Pebbly sand and silt derived from small drainages in the flanks of Las Ventanas Ridge and Horace Mesa. Typically subdivided based on age inferred from geomorphology and soil development. |
| Qafh | Historic alluvial fan material from Mesozoic-cored highlands. Likely up to 1 m thick. |
| Qafy | Younger alluvial fan material from Mezosoic-cored highlands. Alluvium underlying fan surfaces inset upon those of Qafo and bearing weak soils (A/Bw at most), with colors of 10YR 6/3 measured. Likely up to 6 m thick. |
| Qafo | Older alluvial fan material from Mezosoic-cored highlands. Alluvium underlying fan surfaces inset upon by those of Qafy and bearing buried soils and evidence of a strong active soil. Buried soils have Bt and up to Stage II Bk horizons and colors of 10YR 6/3-6/4 and 2.5Y 7/4. Evidence for a Stage III K horizon at the top of these deposits, but this was not observed in outcrop. Likely up to 10 m thick. |

*El Malpais valley alluvium*

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| Qay | Younger alluvium of the El Malpais valley. Fine sand and mud with local fine pebbles, mainly along shallow, low gradient drainages. Active soils and buried soils are typically weak, A/Bw to A/Bt/Bk (Stage I), with clay as fine films on ped faces and bridging grains. Likely up to 2 m thick. |
| Qaec | Calcareous alluvium and eolian material. Fossiliferous sand, mud, and sparse fine pebbles with rare dark gray organic material accumulations. Soil analyzes by White (1989) indicate deposits are up to 100% carbonate. Fossils are mollusk shells, and carbonate casts of grasses and roots are also locally common. Likely up to 3 m thick. |
| Qazo | Older alluvial fan material from Zuni Canyon. Gravel, sand, and silt bearing clasts indicative of derivation from the Zuni Mountain interior, specifically fine pebbles of granite, red siltstone, quartz sandstone, siliceous material, and arkosic sandstone. Distribution suggests transport |

from Zuni Canyon into the El Malpais valley prior to the eruption of Qbz but probably after eruption of Qbc. Thickness unknown, possibly tens of meters in the El Malpais graben.

*Zuni Mountains piedmont alluvium*

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| Qp | Alluvium of the Zuni Mountains piedmont, undivided. Typically subdivided based on age inferred from geomorphology and soil development. Units are extended from work to the west by Timmons and Cikoski (2012). |
| Qpy | Younger alluvium of the Zuni Mountains piedmont, undivided. Combined unit of Qpy1, Qpy2, and Qpy3 of Timmons and Cikoski (2012), mapped where finer subdivision is not readily possible at this scale. Likely up to 3 m thick. |
| Qpy3 | Youngest alluvium of the Zuni Mountains piedmont. Brown silty fine to coarse sand with little soil development. Contains sparse very fine carbonate nodules (Stage I carbonate horizon morphology). Colors of 5YR 6/4 to 7.5YR 5/3 measured. 0-1 m thick. |
| Qpo | Older alluvium of the Zuni Mountains piedmont. Pale to medium reddish brown pebbles to boulders and silty sands with strong soil development. Stage III carbonate horizon morphology common in outcrop. Colors of 5YR 5/4 to 8.5/2 measured, with color controlled by abundance of carbonate. Likely up to 10 m or more thick. |

**Lava flows**

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| Qbm | McCartys flow. Dark gray basalt flow largely unconcealed by eolian material or vegetation. Variably porphyritic, from <1% to 20% phenocrysts, principally of subhedral, <1 mm across pyroxene, but also rare (<3%) plagioclase as subhedral, clear, <1 mm across prismatic crystals. Age estimates range from 2.4 to 3.9 ka (Table 1). Likely 0 to 6 m thick. |
| Qbb | Bandera flow. Lithologically similar to Qbm, though with more fine-grained eolian cover. Consistent age estimates range from 9.17 to 12.5 ka (Table 1). Likely 0 to 6 m thick. |
| Qbz | Zuni Canyon flow. Dark gray to black, generally phenocryst-poor basalt. Up to 3% phenocrysts of translucent greenish pyroxene and olivine, both <1/2 mm across, typically anhedral, and variably degraded to translucent reddish iddingsite(?). Likely 0 to 4 m thick. |
| Qbh | Hoya de Cibola flow. Basalt flows burying Qbc, and buried by Qbm and Qbb, locally concealed by eolian material and vegetation though typically only partially concealed. Likely 0 to 5 m thick. |
| Qbc | El Calderon flow. Dark gray to black basalt with rare fine phenocrysts. Up to 5% phenocrysts <1/2 mm across of mainly subhedral translucent greenish pyroxene and lesser (up to 1% of rock) anhedral translucent greenish olivine. Basalt surface is often largely concealed by eolian material and vegetation, with actual basalt cropping out mainly at breaks in slope, areas of erosion, and areas with relatively high microrelief. Age |

of eruption uncertain due to a wide spread in results, from 34 to 130 ka (Table 1). Likely 0 to 7 m thick.

Qbg — Grants flow. Dark gray to black generally phenocryst-poor basalt underlying and largely concealed by Qbc. To date, only conclusively distinguished as a separate flow by the paleomagnetic work of Cascadden et al. (1997). Here, the contact is placed on a well-defined flow break along the Rio San Jose, and an inferred flow break along the western margin of the El Malpais valley; only the former contact is verified by paleomagnetic work. Rock mass is up to 4% phenocrysts of pyroxene (up to 1 mm across, subhedral, translucent greenish) and <1-2% olivine (euhedral, <1 mm across, translucent greenish). Likely 0 to 7 m thick.

Ttbp — Porphyritic trachybasalt capping Horace Mesa on this quadrangle. Medium gray basalt with up to 5% phenocrysts of mainly plagioclase (up to 6 mm across, translucent white to chalky white, lathe-like subhedral or fractured anhedral shapes, 2-4% of rock mass) and pyroxene (<1-6 mm across, black to dark translucent green, anhedral to subhedral, <1-2% of rock mass). K-Ar age of 3.24 ± 0.09 Ma from Laughlin et al. (1993) thought to be from this flow. 15-25 m thick.

**Mesozoic strata**

Kc — Crevasse Canyon Formation, undivided, including associated tongue of the Mancos Shale. Generally subdivided into constituent members.

Kcda — Dalton Sandstone Member. White to pale brown quartz-rich, variably silty fine to medium sandstone. Thin bedding, typically 10-60 cm thick, with common 1-5 mm thick cross-laminae. Colors of 2.5Y 8.5/1 and 2.5Y 7/2 measured for fresh faces. 34-40 m thick.

Kmm — Mulatto Tongue of the Mancos Shale. Yellowish brown mudstone, mostly siltstone. Strongly planar laminated/bedded mudstone, with wavy beds 2 to 30 mm thick. Colors of 2.5Y 7/4 to 8/3 measured for fresh surfaces, 10YR 7/6 measured for weathered surface. Includes a thin quartz-rich very fine sandstone interval. 50-60 m thick.

Kcs — “Stray” Sandstone Member. Pale brown quartz-rich clean fine sandstone. Thinly bedded, 10-40 cm thick, and massive to weakly internally cross-stratified. Colors of 2.5Y 8/3 to 7/4 measured on fresh surfaces. Includes a 2-3 m thick shale interval, as well as local mudstone interbeds (<5% of exposures). 20-25 m thick.

Kcdi — Dilco Coal Member. Heterolithic unit of interbedded pale brown to gray siltstone, pale brown to tan sandstone, and black coal. Thin bedding to thick laminae; sandstone beds are typically 5-25 cm thick and massive or internally cross-laminated with 1-4 mm thick laminae, while mudstone beds are 3 mm to 3 cm thick, and coal beds are up to 1 cm thick and discontinuous. Sandstone color of 2.5Y 8/4 measured on a fresh face. 35-45 m thick.

Kg — Gallup Sandstone, undivided, including associated tongues of the Mancos Shale. Generally subdivided into constituent members.

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| Kgc | Gallup Sandstone tongue “C”. Pale brown to light yellowish gray quartz-rich silty fine sandstone. Thinly bedded (5-30 cm thick) with common internal cross-laminae 1 mm to 1 cm thick. Color of 10YR 8/4 measured for a fresh face. Designation as unit “C” after Molenaar (1983), previously referred to as “Gallup, main body” by Thaden et al. (1967) and Zeigler et al. (2012). 12-20 m thick. |
| Kgm2 | Upper tongue of Mancos Shale intercalated with the Gallup Sandstone. Poorly exposed, thinly laminated mudstone and siltstone located stratigraphically between Kge and Kgc. 30-36 m thick. |
| Kge | Gallup Sandstone tongue “E”. Pale brown to light yellowish brown, quartz-rich silty-clayey fine sandstone. Thinly bedded (3-50 cm thick), massive with vertical tubular burrows to well cross-laminated, with 1-3 mm thick laminae. Color of 2.5Y 8/4 measured for a fresh face. Unit is capped by a distinctive brown, well indurated, calcite-cemented, muddy fine sandstone, with colors of 10YR 5/4 to 6/3. Designation as unit “E” after Molenaar (1983), previously referred to as “Gallup, upper tongue” by Thaden et al. (1967) and Zeigler et al. (2012). 15-25 m thick. |
| Kgm1 | Lower tongue of Mancos Shale intercalated with the Gallup Sandstone. Poorly exposed, thinly laminated mudstone and siltstone located stratigraphically between Kgf and Kge. 10-15 m thick. |
| Kgf | Gallup Sandstone tongue “F”. Pale brown to pale yellow to gray quartz-rich silty fine sandstone and fine sandy siltstone. Thinly bedded (4-30 cm thick), commonly massive with burrows at the base, grading up into cross-laminated (1-4 mm thick laminae). Colors of 2.5Y 7/1-8/3 measured. Designation as unit “F” after Molenaar (1983), previously referred to as “Gallup, lower tongue” by Thaden et al. (1967) and Zeigler et al. (2012). 12-15 m thick. |
| Km | Mancos Shale, undivided. Claystone to siltstone, with very rare sandstone beds. Typically divided into tongues based on stratigraphic location. |
| Kmrd | Mancos Shale, equivalent to the Rio Salado and D-Cross Tongues. Light gray to medium gray to pale brownish gray, well-laminated gypsiferous siltstone to claystone and rare sparry gypsum beds. Thinly bedded, with beds up to 6 cm thick, commonly internally laminated, with laminae <1 to 1 mm thick. 45-55 m thick. |
| Kd | Dakota Sandstone, undivided. Sandstone, siltstone, and mudstone. Typically divided into tongues based on stratigraphic location. |
| Kdt | Dakota Sandstone, Twowells Tongue. Light yellow to white, quartz-rich, variably silty fine sandstone and local siltstone. Typically more massive and thicker bedded base, and more cross-bedded and thinner bedded top. Beds from 1 m thick at base to 25-40 cm thick at top. Color of 2.5Y 7/4 measured on a fresh face. Gradational basal contact. 9-11 m thick. |
| Kmw | Mancos Shale, Whitewater Arroyo Tongue. Light gray to dark gray siltstone to claystone. Generally very poorly exposed. Color of 2.5Y 7/2 measured. 4-6 m thick. |
| Kdp | Dakota Sandstone, Paguate Tongue. Light yellow to pale brown, variably silty fine to medium sandstone. A massive base grades up into a bedded |

but internally massive middle, followed by a bedded and internally cross-stratified top. Beds are 4-20 cm thick, cross-strata 1-12 mm thick. Unit tends to coarsen upsection, from silty very fine to clean fine-medium sandstone. Colors of 2.5Y 7/3-8/3 measured on fresh faces. 9-12 m thick.

Kmc Mancos Shale, Clay Mesa Tongue. Black to brown claystone to siltstone. Brown color of 10YR 5/4 measured; brown color may be an iron oxide stain. 18-24 m thick.

Kdc Dakota Sandstone, Cubero Tongue. Pale brown to light yellow variably silty fine sandstone. Thinly bedded, particularly where not bioturbated (30-50 cm thick where massive, 2-12 cm thick where cross-bedded). Vertical and subhorizontal burrows common. Unit includes a ~2 m thick medial section of mudstone, separating two sandstone intervals. 9-12 m thick.

Kdou Dakota Sandstone, upper Oak Canyon Member. Black to pale brown gypsiferous claystone to siltstone. Strongly laminated mudstone, commonly wavy, up to 4 mm thick. Local very fine sandstone beds up to 3 cm thick. Colors of 2.5Y 5/3, 7/2, and black (value <2.5, chroma ~1) measured. Unit includes a ~2 m thick sandstone interval dividing two mudstone intervals. 26-30 m thick.

Kdol Dakota Sandstone, lower Oak Canyon Member. Pale brown to white, variably silty fine to medium sandstone and lesser pebbly sandstone and siltstone. Thin beds (1-10 cm thick beds) that are typically more massive at the base and internally planar and cross-laminated toward the top. Vertical and subhorizontal burrows are common. Locally carbonaceous. Pebbles at the base are up to ½ cm across, poorly sorted, generally well rounded, and principally of light to medium brown siliceous material with rare quartzite and sparse granite. 8-10 m thick.

Jm Morrison Formation, undivided. Interbedded pale yellow to light brown sandstone, varicolored mudstone, and lesser conglomerate. Lower sandstones are of silty fine sand, typically pale yellow in color (2.5Y 8/3 measured), and are indistinctly bedded with cross-laminae. Upper sandstones and conglomerates are pale brown to white, of quartz-rich silty fine to coarse sand, generally in thin beds (5-8 cm thick) with common, well-expressed cross-laminae. Pebbles, only observed in the upper part of the unit, are up to 1 cm across, moderately sorted, subrounded to rounded, and mainly of siliceous material with rare granites (up to 2% of beds) and sparse white to gray quartzites (<<1%). Mudstones are clay to silt, with colors of 5YR 5/3, 5GY 8/1, and 5Y 8/2 measured. Use of Jm here differs from the previous maps of Thaden et al. (1967) and Maxwell (1986) in that the strongly cross-bedded sandstones and conglomerates between the varicolored mudstones and bioturbated lower Dakota sandstones are included in the Morrison and not considered a part of the Oak Canyon Member of the Dakota. Pinches out to the south. 0-30 m thick.

Jb Bluff Sandstone. Light gray to strong olive colored, strongly cross-bedded, dominantly eolian sandstone with local fluvial sandstone. Variably silty fine to medium sands, mainly of quartz. Thin to medium beds (up to 1.5 m

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| | thick observed), tabular and wedge-shaped, with steep, large-scale, eolian cross-laminae. Local fluvial beds are thinner, up to 20 cm thick, with low-angle, small-scale cross-laminae. Colors of 5Y 8/2 and 2.5Y 6/6 measured. Forms bold cliffs. 85-90 m thick. |
| Js | Summerville Formation. White to pale yellow, very poorly exposed sandstone, mudstone, and limestone conglomerate(?). One poor exposure suggests the presence of limestone pebble conglomerate channels, with subrounded to rounded, poorly sorted fine to medium pebbles in a silty fine to coarse sand matrix; given the poor exposure, however, it is possible this conglomerate is actually a caliche-cemented Quaternary deposit inset upon the Summerville sandstones. Colors of 2.5Y 8/1 to 7/3 measured. 13-16 m thick. |
| Jt | Todilto Formation. Gypsiferous light to dark gray fine-grained limestone. Typically <5% of fresh faces is visible grains (locally up to 20%), with <1-2% fine (<1 mm across) circular fossils. Thinly bedded, 0.5 to 10 cm thick. Colors of 2.5Y 6/1 to 7/1 measured. 5-7 m thick. |
| Je | Entrada Sandstone. Pink to light reddish brown silty fine sandstone and siltstone. Grains are moderately to poorly sorted, very silty with rare medium sand grains. Indistinctly thinly bedded (2-10 cm thick), but well cross-bedded. Color of 2.5YR 7/4 measured. 45-50 m thick. |
| Ŧu | Triassic, undivided. Cross-section only. Includes both Ŧc and Ŧm. 540-550 m thick. |
| Ŧc | Chinle Formation, undivided. Poorly exposed red mudstone at the top, reddish brown sandstone and pebble conglomeratet at the base; middle of unit is not exposed. Basal contact placed on the first pebble conglomerate. |
| Ŧm | Moenkopi Formation. Slope-forming red to reddish brown mudstones along the eastern edge of the quadrangle. Poorly exposed. Less than 5 m thick. |

**Paleozoic and older strata**

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| Psa | San Andres Formation. Light to dark gray limestone and dolomite. Exposed only along the eastern margin of the quadrangle. 75-80 m thick. |
| Pg | Glorieta Sandstone. Cross section only. 40-45 m thick. |
| Py | Yeso Formation. Cross section only. 380-385 m thick. |
| Pa | Abo Formation. Cross section only. 285-290 m thick. |
| IPu | Pennsylvanian strata, undivided. Cross section only. Only locally present in the Zuni Mountains, ~150 m thick in the Gottlieb #1 lithologic log. |
| pꞒu | Precambrian rocks, undivided. Cross-section only. |

**Intrusive rocks**

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| Tib | Intrusive basalt. Dark gray to dark brownish gray and black pyroxene-plagioclase basaltic porphyry dikes. Rock mass is up to 10% greenish-translucent subhedral pyroxene, 1-3% clear to white subhedral plagioclase, and sparse reddish translucent crystals, possibly iddingsite replacing olivine. All phenocrysts <1 mm across. Dikes are 0 to 1 m wide. |

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Table 1: Summary of geochronologic data for the Grants SE basalt flows.

| Unit | Age[1] (ka) | ±2σ [2] | Type[3] | Ref.[4] | Latitude | Longitude | Comments |
|---|---|---|---|---|---|---|---|
| Qbm | 2.97 | 0.12 | $^{14}C$ | L94 | 34°56.01'N | 107°50.33'W | |
| | 3.01 | 0.14 | | | | | |
| | 2.5 | 1.1 | $^{3}He$ | L94 | 35°05.16'N | 107°46.52'W | |
| | 2.4 | 0.6 | | | | | |
| | 3.9 | 1.2 | $^{36}Cl$ | DP04 | 34°55.97'N | 107°50.45'W | Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions |
| Qbb | 9.17 | 0.14 | $^{14}C$ | L94 | 35°00.32'N | 108°04.35'W | |
| | 9.81 | 0.12 | | | | | |
| | 11.0 | 1.1 | $^{3}He$ | L94 | 34°59.64'N | 108°05.22'W | |
| | 10.0 | 1.8 | | | | | |
| | 12.5 | 1.4 | $^{3}He$ | L94 | 34°59.57'N | 108°05.48'W | |
| | 11.2 | 0.6 | $^{36}Cl$ | DP04 | 34°59.55'N | 108°05.30'W | Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions |
| | 41 | 7 | Ar/Ar | M94 | | | Inconsistent age, possibly from excess argon |
| Qbh | 50 | 14 | Ar/Ar | LWup | | | Uncertain age, possibly suffers from excess argon |
| Qbc | 128 | 33 | K-Ar | CL88 | | | |
| | 54 | 50 | K-Ar | L93 | 35°07.52'N | 107°20.55'W | |
| | 34.7 | 3.0 | $^{36}Cl$ | DP04 | 35°04.49'N | 107°45.29'W | Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions |
| | 115-120 | -- | PM | C97 | | | Suggested to have erupted during the Blake geomagnetic polarity event |
| Ttbp | 3238 | 85 | K-Ar | L93 | 35°05.17'N | 107°42.50'W | Lower lava flow from southeastern tip of Horace Mesa |

[1]: Age as published; no attempt made to normalize values. $^{14}C$ ages are not calibrated calendar ages.

[2]: Uncertainty as published.
[3]: PM – age from comparison of radiometric ages and paleomagnetic data to established paleomagnetic sequence; $^{14}C$ ages date material from buried soils immediately underlying the flows; $^{3}He$ and $^{36}Cl$ are cosmogenic surface exposure ages; $^{40}Ar/^{39}Ar$ and K-Ar are crystallization ages.
[4]: C97 – Cascadden et al., 1997; CL88 – Champion and Lanphere, 1988; DP04 – Dunbar and Phillips, 2004; L93 – Laughlin et al., 1993; L94 – Laughlin et al., 1994; LWup – Laughlin and WoldeGabriel, unpublished data, cited in Laughlin and WoldeGabriel., 1997; M94 – McIntosh, 1994.