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# *Geologic transect across the northern Sierra Madre Occidental volcanic field, Chihuahua and Sonora, Mexico*

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## ABSTRACT

**Eleven individual mapping projects by graduate students at The University of Texas at Austin have been compiled into a regional geologic map that comprises a 285-km-long east-west transect of the middle Tertiary Sierra Madre Occidental volcanic field at 28° to 28°30′ north latitude. The map area extends across the entire Sierra Madre Occidental plateau and eastward, to include faulted remnants of the volcanic field in central Chihuahua. In order to portray the timing and evolution of the middle Tertiary volcanism at regional scale, the original volcanic map units have been condensed into a set of nine major units by grouping conformable sequences that have similar K-Ar ages. More recently obtained $^{40}Ar$-$^{39}Ar$ ages were used to refine the groupings. Original mapped and inferred faults, and known and interpreted caldera margins are also shown.**

**During the mapping, suites of samples were collected for geochemistry and geochronology. A total of 223 such sample locations are plotted on the transect map. A link is provided between these locations and a master table that lists the type of data available for each sample. The original K-Ar geochronology and geochemistry (major-elements by wet chemistry and limited trace-element measurements) have been augmented subsequently by expanded trace-element concentration data, U-Pb, $^{40}Ar$-$^{39}Ar$ dating, and measurements of radiogenic and stable isotope ratios conducted on some of the original samples. All of the available data are given in a series of tables.**

**The field relations and analytical data reveal important spatial and temporal patterns of activity across a large felsic igneous province. These patterns and their implications will be explored in future papers. The primary purpose of this compilation has been to make the information available to those interested in pursuing further investigations within this seriously understudied volcanic field.**

**Keywords:** Mexico; Sierra Madre Occidental; ignimbrite field; geology; geochronology; geochemistry.

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## INTRODUCTION

The mid-Tertiary Sierra Madre Occidental volcanic field of western Mexico is the largest contiguous volcanic province in North America (McDowell and Clabaugh, 1979). Its uninterrupted central belt covers ~300,000 km$^2$ (Fig. 1), an area roughly equivalent to that of the state of Arizona. It is probable that the field originally extended well eastward into the Basin and Range province of Chihuahua to include perhaps 100,000 km$^2$ of additional area. It is possible that the volcanic cover originally was continuous with contemporary deposits in southwestern New Mexico-southeastern Arizona, west Texas, and the central plateau of Mexico.

Pyroclastic materials emplaced as thick ignimbrite sheets are the dominant lithology of the Sierra Madre Occidental volcanic field. These erupted primarily from calderas 20–30 km in diameter (Swanson and McDowell, 1984). Within the core area of the Sierra Madre Occidental, the base of the volcanic section is rarely exposed, because thick caldera-fill sequences are probably present beneath any location. Consequently, the total thickness is difficult to determine, but estimates of composite thickness range from 1 to 1.5 km (McDowell and Clabaugh, 1979). Outside of the central core, where caldera sources are more widely spaced, it is common to encounter the base of the volcanic section. Exposures in those areas are typically 500 m or less in thickness.

Location of the Sierra Madre Occidental volcanic field near and parallel to the western margin of the North American plate, the timing of emplacement during the mid-Tertiary, and the general calc-alkaline composition of the rocks all suggest a relationship of the volcanism to subduction of the Farallon Plate beneath North America (Ferrari et al., 2007). Nevertheless, the tectonic origin of the Sierra Madre Occidental remains an enigma because of the very large flux of magma emplaced over a short interval of time, the evolved composition (rhyodacitic to rhyolitic) of much of that material, and the overlap in timing with the end of Farallon plate subduction. Notwithstanding these uncertainties, a relative lack of published information is the major hindrance to understanding the Sierra Madre Occidental volcanic field

This publication attempts to mitigate this problem for the northern Sierra Madre Occidental volcanic field by summarizing major portions of a long-term project by students and faculty at the Department of Geological Sciences of The University of Texas at Austin (UT). The emphasis has been placed upon field relationships from a series of eleven contiguous mapped areas (Table 1) that cover most of the east-west extent of the Sierra Madre Occidental volcanic field between 28° and 28°30′ N latitude. The original maps have been compiled at a scale of 1:250,000 (see map), and local stratigraphic sections have been generalized into a regional stratigraphic scheme (Table 2; Fig. 2). Geochemical and/or geochronologic data for sample localities shown on the map are compiled in Tables 3–8.

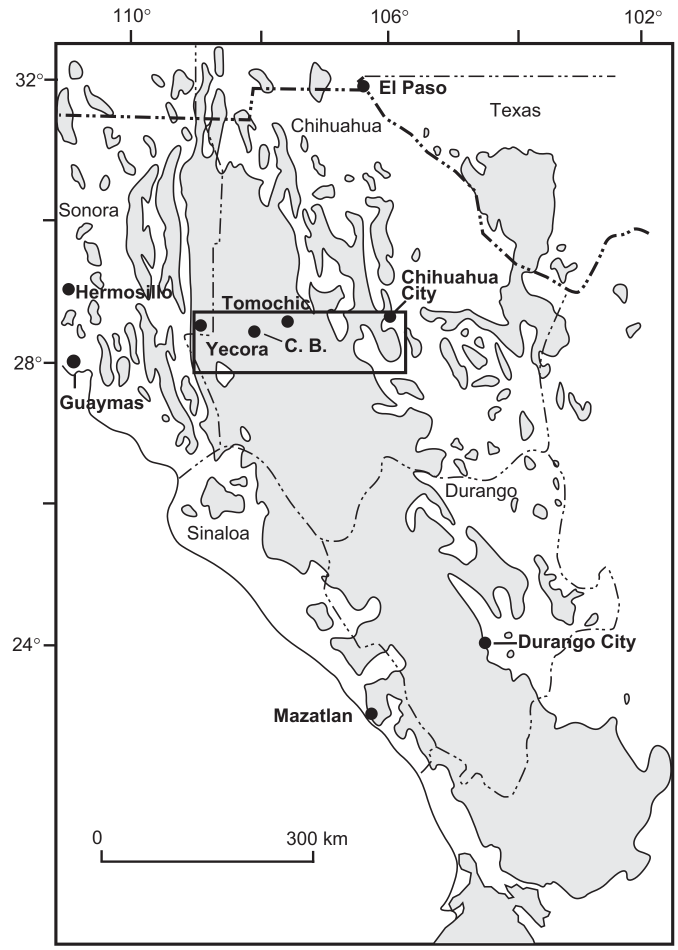



Figure 1. The distribution of Eocene to early Miocene volcanic rocks in western Mexico and adjacent areas of the United States is shown in gray. The black rectangle encloses the area of this map transect. C.B.—location of the Cascada de Basaseachic.

## HISTORY OF UT STUDIES IN THE SIERRA MADRE OCCIDENTAL VOLCANIC PROVINCE

### Beginnings

Studies begun at UT in the late 1960s still comprise the only sustained investigation of the basic stratigraphy and chronology of volcanism in the Sierra Madre Occidental. Impetus for the project came from Professor J. Hoover Mackin, who obtained funding from NASA based upon the premise that manned Apollo missions could encounter ignimbrite plateaus as a prominent feature of the lunar surface. Mackin's interests included the geomorphic features developed upon the ignimbrite surfaces, as well as the distribution and nature of the ignimbrites themselves. He encouraged Richard Waitt (a student) to begin a master's project along the Durango-Mazatlán highway. They chose two study

TABLE 1. DESCRIPTION OF MAPPING PROJECTS

| No. | Reference | Degree | Area | Field Years | Base | Supervisor |
|---|---|---|---|---|---|---|
| 1 | Bockoven (1980) | Ph D. | Yecora-Ocampo | 1977–1978 | Air photos | McDowell |
| 2 | Wark (1989) | Ph D. | Tomochic | 1984–1986 | Topo 1:50000 | McDowell/Smith |
| 3 | Kempter (1986) | M.A. | Tomochic | 1984–1986 | Topo 1:50000 | McDowell |
| 4 | Swanson (1977) | Ph D. | Tomochic-Ocampo | 1974–1976 | Topo 1:250000 | Clabaugh |
| 5 | Duex (1983) | Ph D. | Cuauhtemoc–La Junta | 1978–1980 | Air photos | McDowell |
| 6 | Stimac (1983) | M.A. | Cusihuiriachic-Cuauhtemoc | 1982–1983 | Topo 1;50000 | McDowell |
| 7 | Wark (1983) | M.A. | Buenos Aires | 1981–1982 | Topo 1:50000 | McDowell |
| 8 | Ide (1986) | M.A. | Laboricita–General Trias | 1983–1984 | Topo 1:50000 | McDowell |
| 9 | Conlon (1985) | M.A. | General Trias–Tutuaca | 1983–1984 | Topo 1:50000 | McDowell |
| 10 | Cook (1990) | M.A. | Palomas | 1983–1984 | Topo 1:50000 | McDowell |
| 11 | Megaw (1979) | M.A. | Sierra Pastorias | 1977–1978 | Topo 1:50000 | Clabaugh |

*Note*: Numbers 1–11 correspond to those on map inset.

areas along the highway, for comparison of the gently tilted and featureless plateau surface to the deeply eroded canyons (barrancas) at the western plateau margins. Unfortunately, Mackin passed away while this project was still under way.

Following this unexpected development, Professors Stephen Clabaugh and Daniel Barker stepped in to ensure completion of Waitt's work (Waitt, 1970). Being petrologists, they increased emphasis on the volcanic stratigraphy and petrology-geochemistry of the field. With the completion of a laboratory for K-Ar geochronology by McDowell at UT, determination of the timing of volcanism was also included in the study. One reconnaissance introduction to the vast Sierra Madre Occidental province was sufficient to convince McDowell to devote most of the K-Ar lab efforts to the timing of events there.

## Durango Phase

Clabaugh took the lead in administering the NASA funding, redirecting its scope, and recruiting graduate students to continue studies along the Durango-Mazatlán highway, which at that time was the only paved route across the Sierra Madre Occidental between Guadalajara and the U.S. border (Fig. 1). This phase of the project was hampered in the field by access limitations, lack of topographic maps at scales less than 1:250,000, and an absence of systematic aerial photography other than that obtained for special projects. The mapped areas were restricted, particularly along the western part of this transect (McDowell and Clabaugh, 1979), where the highway maintains elevation along an increasingly narrow ridge before plunging steeply

TABLE 2. EXPLANATION OF UNITS

| | |
|---|---|
| Quaternary–Late Tertiary | |
| QTal | Alluvium. Unconsolidated to poorly consolidated. |
| Late Tertiary | |
| Ts | Coarse, generally lithified clastic deposits, Associated with NW trending linear basins. |
| Oligocene–Eocene | |
| Tuml | Upper mafic lavas; generally of basaltic andesite composition, generally above or interlayered with Tfr and the uppermost units of Tv. |
| Tfr | Ferroaugite rhyolite (Cameron and others, 1980); distinctive rhyolitic ignimbrites characterized by Fe-rich pyroxene and/or fayalitic olivine; ca. 30 Ma. |
| Tvu | Felsic volcanic rocks undivided; predominantly pyroclastic. |
| Tv7 | Felsic lava flows and ignimbrites, intercalated with Tuml in western part of transect; ca. 23 Ma. |
| Tv6 | Major interval of felsic ignimbrites generally poorly welded, with related intermediate and felsic lavas; ca 30 Ma. |
| Tv5 | Major interval of ignimbrites and associated units; 31.0–32.5 Ma. |
| Tv4 | Major interval of ignimbrites and associated units; 33–35.5 Ma. |
| Tv4i | Small rhyolitic intrusions marking caldera structural boundaries in eastern portion of transect. |
| Tv3 | Locally thick accumulations of felsic tuffs and felsic and intermediate lavas; mainly in eastern portion of transect; 36–37 Ma. |
| Tv2 | Oldest felsic ignimbrites throughout transect area; in places intercalated with thick intermediate lava flows; 38–39 Ma. |
| Tv1 | Extremely localized occurrences of intermediate and felsic lava flows in eastern part of transect; 40–43 Ma. |
| Early Tertiary and Late Cretaceous (?) | |
| KTvs | Accumulations of intermediate to felsic lavas and pyroclastic deposits. |
| Mesozoic | |
| Ms | Mesozoic sedimentary rocks, undivided. |
| Intrusions | |
| Ti | Small intrusions of middle Tertiary age. |
| KTi | Small intrusions of Late Cretaceous and early Tertiary age, generally equigranular granodiorite. |

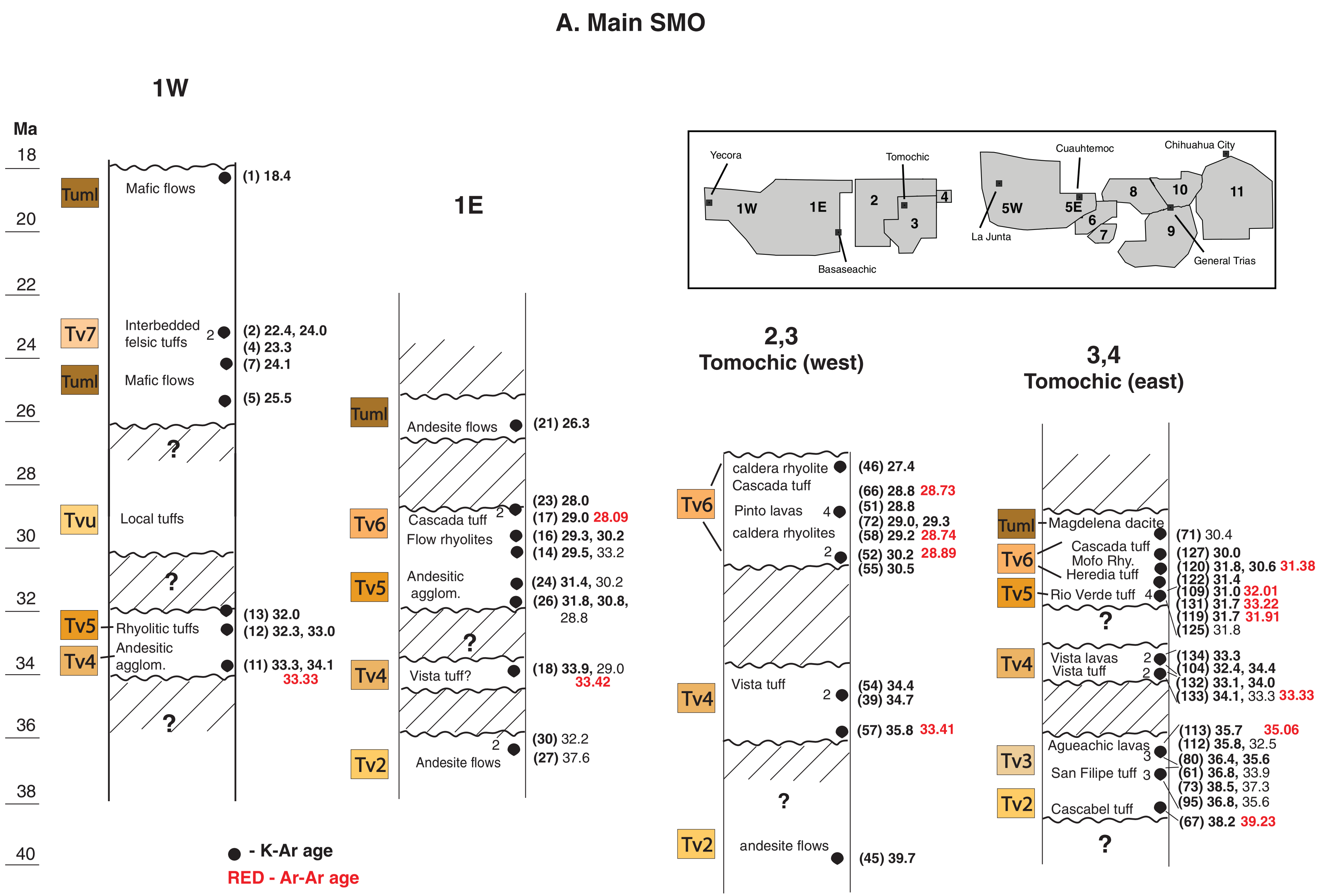



Figure 2 (*continued on following pages*). A series of time-stratigraphic charts portrays the general distribution of volcanic units across the transect from west to east in three panels. The numbers above the columns and in the inset refer to the individual map areas (see Table 1 and inset of the transect map). The columns contain many of the names of major map units used in the original mapping. The colored flags to the left of the columns show their assignment to the units used to construct the transect map; these colors match those on the transect map. Also shown are the stratigraphic positions of dated samples; numbers in parentheses correspond to entries in column 1 of Tables 5–7. Numbers in bold are K-Ar and U-Pb ages used to assign local map units to the transect units; other ages are shown in normal font style. Numbers in red are $^{40}Ar$-$^{39}Ar$ ages for the same samples (see text). Note the time markers at the left side of each panel. Panel A includes the main Sierra Madre Occidental and panels B and C include mapped areas in central Chihuahua.

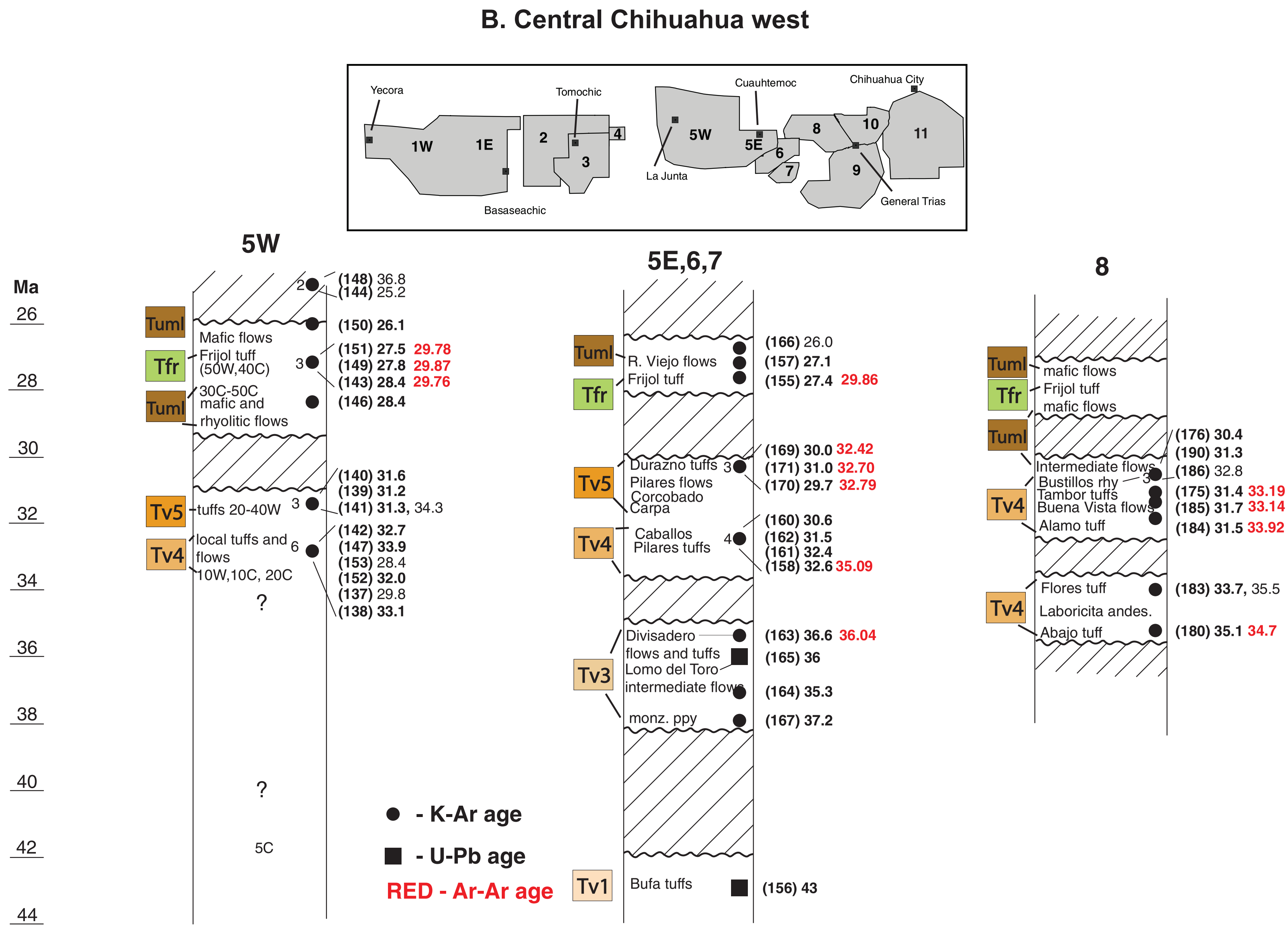



Figure 2 (*continued*).

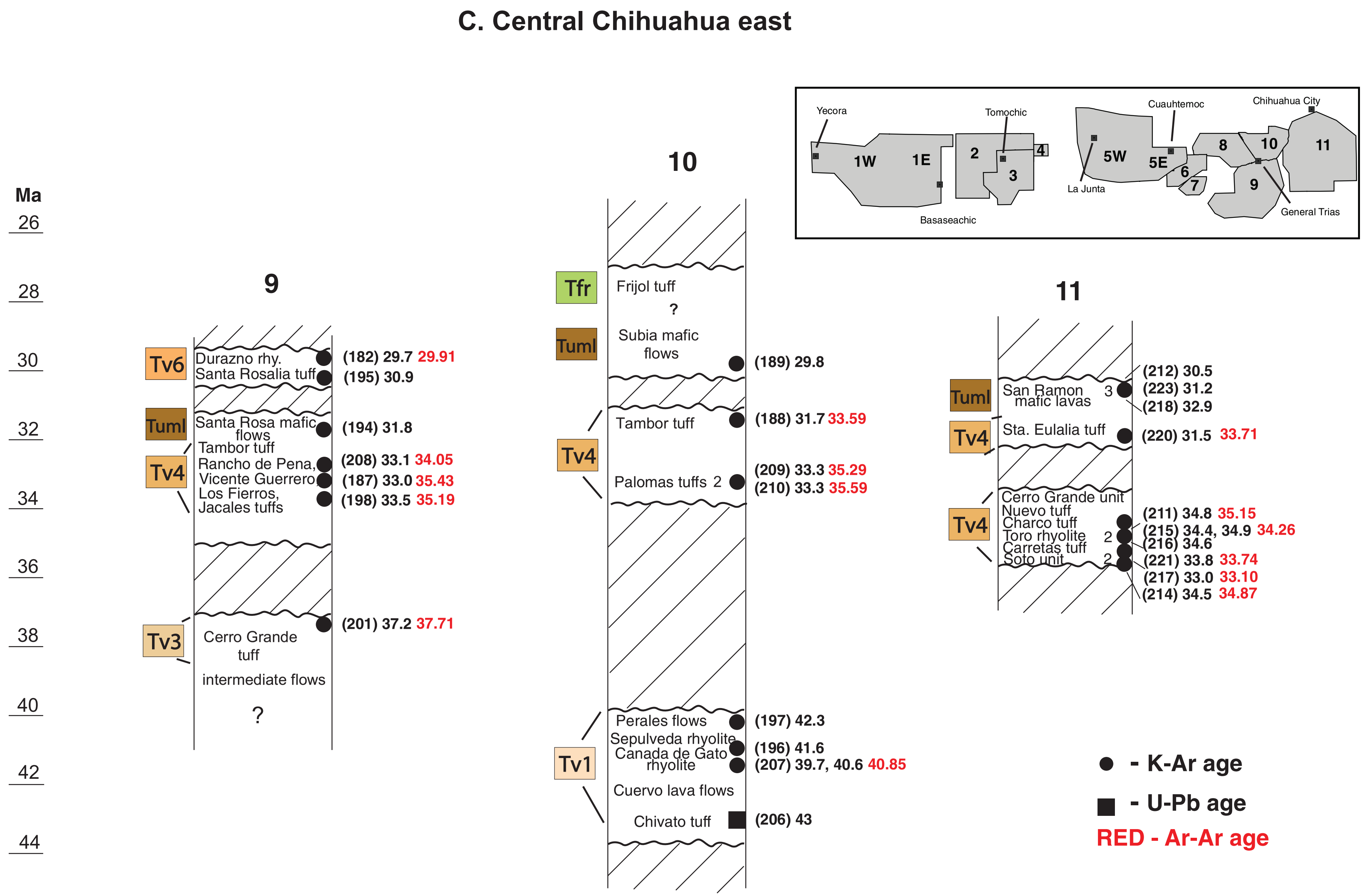



Figure 2 (*continued*).

westward toward its termination at Mazatlán on the Gulf of California. Consequently, Waitt used a highway elevation map as his primary control; the western study area of his mapping was as much a cross section as a plan map. Subsequent mapping in the central part of the Sierra Madre Occidental volcanic field utilized a narrow band of aerial photography made for construction of the highway (Wahl, 1973).

Mapping efforts were more readily facilitated at the eastern end of this transect, in the vicinity of Durango City. A team of students (Keizer, 1973; Swanson, 1974; Lyons, 1975) working there was able to extend the stratigraphy of Waitt's eastern area into the surrounding area and to document the first caldera complex for the Sierra Madre Occidental volcanic field (Swanson et al., 1978). This effort also was the first to demonstrate that ignimbrite sources in the Sierra Madre Occidental volcanic field were likely to be quite similar in size and structure to those within classic ignimbrite provinces in the United States and elsewhere, including the San Juan volcanic province of southwestern Colorado (Lipman, 1984). Using a comparison by area with the San Juan province, Swanson and McDowell (1984) estimated that 350–400 such calderas are potentially present in the Sierra Madre Occidental province.

K-Ar dating associated with the Durango studies established the first estimates of timing for volcanism in the Sierra Madre Occidental volcanic field (McDowell and Keizer, 1977). The ages revealed two discrete pulses of activity, from 31 to 28 Ma in the Durango area, and a cluster of events at 23 Ma in the western portion of the transect. The Durango-Mazatlán studies also established that the ignimbrites mostly were true rhyolites in composition and follow a high-potassium calc-alkaline trend. All together, these studies provide a transect of the Sierra Madre Occidental volcanic field along the Durango-Mazatlán highway at 24° N latitude (McDowell and Clabaugh, 1979).

**Studies in Chihuahua**

In the middle 1970s, two developments facilitated expansion of our studies further to the north in the state of Chihuahua. The first of these was the initiation of a program by the Mexican government to begin aerial photography and to produce topographic maps at 1:250,000 and 1:50,000 scales for the entire country. The other development was construction to extend a second paved highway across the Sierra Madre Occidental connecting the cities of Chihuahua and Hermosillo (Sonora). However, both of these developments lagged behind the start of our mapping in Chihuahua, and the earliest studies failed to benefit fully from them.

The eleven studies compiled for this northern transect are listed in Table 1, where they are numbered by location from west to east. The pioneering project was by Swanson (1977) who continued his studies in Mexico for a Ph.D. dissertation. He chose the area around the town of Tomochic (Fig. 1) based upon satellite images that indicated the presence of a "caldera-like" feature. He mapped three areas in reconnaissance using aerial photos, but without the benefit of 1:50,000 scale topographic maps (Swanson, 1977). Swanson documented a caldera complex from which two major ignimbrite units were erupted, at 34 and 31 Ma (Swanson and McDowell, 1985). The Tomochic area was thus shown to be of prime importance, and a "second generation" of studies was initiated there after better air photos and base maps had become available (Kempter, 1986—area 2; Wark, 1989—area 3). Kempter and Wark refined much of Swanson's earlier mapping, except for a small portion of his easternmost map area. This portion of Swanson's original mapping includes important and easily accessible outcrops along the highway ascending the eastern flank of the Sierra Madre Occidental (area 4). It has been included in the compilation following revision to accommodate additional stratigraphic and structural detail, and expanded K-Ar geochronology provided by the subsequent studies (see next section). Together these studies have established the Tomochic caldera complex as a "type locality" for the northern Sierra Madre Occidental volcanic province (Wark et al., 1990; Wark 1991).

Two new projects were undertaken following Swanson's study (Table 1). One was located to the west, reaching across the Sierra Madre Occidental plateau as far as the town of Yécora in eastern Sonora (Bockoven, 1980—area 1). The second included a large area to the east, in the Chihuahua Basin and Range (Duex, 1983—area 5). Both of these should be considered reconnaissance as they also preceded the availability of 1:50,000 scale topographic maps for the areas. Also, the Chihuahua-Hermosillo national highway was still under construction west of Tomochic at the time of Bockoven's mapping. Because of the difficult access in the central part of the Sierra Madre Occidental, that project was originally begun as a two-person study. However, an unfortunate automobile accident claimed the life of one of the students (R.P. Keizer) and seriously injured Bockoven. Subsequently, the project was expeditiously curtailed.

Later UT studies in Chihuahua were facilitated by the availability of comprehensive aerial photography and topographic maps at 1:50,000 (Table 1). Aside from differences in scale and detail of mapping, all of the projects followed a similar pattern. A local volcanic stratigraphy was established and each major map unit was given an informal name (an exception was Bockoven's study for which most of the units were identified by lithology). In each area, the stratigraphy provided a sampling framework for K-Ar age determinations, major-element chemical analyses by wet chemistry, and a very limited array of trace-element analyses by X-ray fluorescence. As is explained later, these data subsequently have been supplemented by more comprehensive trace-element analyses and more precise geochronology.

These eleven projects comprise a transect that extends westward for 285 km from Chihuahua City to the town of Yécora, which is just to the west of the Chihuahua-Sonora state border (Fig. 1). At this latitude (between 28° and 28°30′ N), the distribution of mid-Tertiary volcanic rocks is wider than in Durango, such that the eastern part is within the Chihuahua segment of the Mexican Basin and Range province (Henry and Aranda-Gómez, 1992; 2000). A broad valley located between map areas 4 and 5 (Table 1) that contains Late Tertiary to modern sediments is used here as a boundary between the relatively unfaulted Sierra Madre Occidental plateau and the basin and range of central Chihuahua.

This compilation does not include additional UT studies of Tertiary volcanic rocks in the Sierra Madre Occidental and eastern Chihuahua that are in isolated locations. Many of these have been published previously (e.g., Keller et al., 1982) or will be included in separate publications. The information compiled is limited to that in studies by UT graduate students, staff, and faculty. We hope that by providing a record of these basic studies, we will stimulate and focus future investigations aimed toward furthering our understanding of this vast volcanic province. Those interested in greater detail than shown on the compiled map and/or petrographic information about the samples analyzed, can access the theses and dissertations by interlibrary loan from The University of Texas at Austin library system.

## CONSTRUCTION OF THE 1:250,000 SCALE MAP

The best available versions of the original maps, normally either a folded blueline print, a blackline print, or a mylar print, were scanned into a computer file. Intensity and contrast were adjusted and the maps were rotated to a north-south parallel using Adobe Photoshop. The transect area covers parts of three 1:250,000 topographic maps (UTM H12-12, H13-10 and H13-11; Instituto Nacional de Estadística Geografía y Informática of Mexico). These were obtained on a computer disk, and the east and west borders of the maps were trimmed using Photoshop so that they could be stitched into a seamless base map. This map was then imported to ArcGIS and georeferenced to the NAD 83 datum. Because the transect area crosses a major UTM grid boundary, the coordinate system chosen was decimal degrees.

The eleven geologic maps were georeferenced to the topographic base map using common reference points. For those maps with a topographic base, the UTM 10 km grid provided a convenient reference. Those without such a base were more of a challenge. Most streams within the transect area are ephemeral, and stream courses chosen from inspection of the aerial photos did not necessarily correspond to those printed on the published topographic maps. Streams were thus of dubious use as tie points. Intersections of paved roads, intersections of paved roads and railroad lines, and a few distinctive topographic features shown on both maps were the only reliable ties. The quantity of these ties was insufficient to remove all original distortion for some maps, and those distortions that remain are reflected in mismatches between geologic and topographic map.

Using ArcGIS, all geologic contacts, faults, and original map boundaries were digitized and attributed as originally drawn by the student mappers. Inferred caldera boundaries are shown as well. Great effort was made to remain faithful to the original maps, but some compromise was required in extending contacts to map boundaries or in designating areas within the map having minimal or uncertain information as "unmapped." Some units that were insignificant at final scale were ignored. Stratigraphy within the small but important area included from Swanson (1977—area 4) was refined through consultation with Swanson, Kempter, and Wark, in order to approximate the detail of later mapping in the Tomochic area. Original structural data were not plotted, because they represent foliation attitudes for individual units that have been grouped for this map (see below). Digitizing was performed for appearance at 1:250,000 and may look somewhat ragged at magnification. No attempt was made to fill in unmapped areas between the project maps, or to extend mapping outside of the original map boundaries.

## TRANSECT MAP UNITS (TABLE 2)

### Middle Tertiary Volcanic Units

As the major focus of this compilation, development of a stratigraphy to portray the middle Tertiary volcanic rocks consistently and at appropriate scale across the entire transect area has been of primary importance. The original map units are not suitable because they are too finely subdivided and because too few correlations across map boundaries have been established. Conversely, a designation as "Tertiary volcanic rocks, undivided" would represent no improvement over existing state and regional geologic maps, or even the early reconnaissance traverses of the last century (Hovey, 1905; 1907; King, 1939). The method developed was based upon the observation that nearly every mapped area contains coherent groups of volcanic units that have reasonably well-clustered K-Ar ages. This combination of stratigraphic coherence and age groupings was used to define the regional units portrayed in the transect map (Table 2). This scheme is not completely satisfactory, because the two-sigma uncertainty of 1–2 Ma for any single K-Ar age is too large for reliable assignment in some cases. Consequently, more precise $^{40}Ar$-$^{39}Ar$ ages obtained recently have been used to refine the groupings and their age limits. The three panels of Figure 2 along with Appendix Table 1, illustrate how the major original units have been grouped into the units used on the map, and show their general distribution across the transect area. The K-Ar, U-Pb, and $^{40}Ar$-$^{39}Ar$ ages are indicated in their relative stratigraphic positions (where known). Figure 2A covers the main Sierra Madre Occidental (map areas 1–4), and Figures 2B (areas 5–8) and 2C (areas 9–11) include the central Chihuahua portion of the map.

Throughout the transect area, the volcanic sequence is dominated by ignimbrites. Rhyolite lavas are prominent only locally and volcanogenic sediments are uncommon. Over most of the map area, this volcanism occurred between 43 and 28 Ma. Rocks of this interval have been divided into six map units, numbered Tv1 through Tv6 from oldest to youngest (Table 2). In the western part of area 1, the volcanism is significantly younger, ca. 23 Ma. Unit Tv7 is used to delineate these distinctly younger rocks. Each of these transect units was assigned a nominal time interval that encompasses most of the available ages for its dated components. There is no requirement or expectation, however, that the transect units are the same age everywhere. A general designation of Tvu is used for some exposures of

Tertiary volcanic rocks that are uncorrelated and undated, primarily in the westernmost part of the map area. One subunit, Tv4i, denotes rhyolitic domes and necks that are arrayed in a circular pattern and appear to mark the caldera source for some of the ignimbrites of unit Tv4 in the eastern part of the map (area 11). Ti indicates small intrusives that are related to the middle Tertiary volcanism.

Two additional map units that are used for the middle Tertiary volcanic rocks have been based upon rock types described in previous regional studies of the northern Sierra Madre Occidental (Cameron et al., 1980; 1989). Unit Tfr comprises ferroaugite rhyolites that are characterized by Fe-rich clinopyroxenes and olivines (Cameron et al., 1980). These ignimbrites are found only in the central Chihuahua portion of the map (areas 5–10), but are more prominent between 50 and 100 km to the north-northeast of Chihuahua City in areas mapped by R.L. Mauger and students (Mauger, 1983a, 1983b, 1988; Mauger and Dayvault, 1983), where they have been dated by K-Ar at ca. 30 Ma (McDowell and Mauger, 1994). Unit Tuml, for "upper mafic lavas," is used for a mafic lava unit found at or near the top of volcanic sections throughout the map area. The rocks are mostly of basaltic andesite composition. They probably correspond to the Southern Cordilleran Basaltic Andesite suite of Cameron et al. (1989), who showed that such lavas are prominent elsewhere in the northern Sierra Madre Occidental and in the southwestern U.S. Cameron et al. (1989) suggested that the Southern Cordilleran Basaltic Andesite suite is related to extensional deformation that post-dates the tectonic environment that existed during ignimbrite emplacement. However, Wark (1991) demonstrated that similar mafic lavas are intercalated with, and probably genetically related to, the evolution of the rhyolitic ignimbrites at the Tomochic caldera complex. Throughout the map area, the upper mafic lavas are commonly found intercalated with the youngest rhyolite units (Tfr, Tv6 and Tv7).

### Post-Tv Map Units

Throughout the Chihuahua Basin and Range and in the westernmost part of the Sierra Madre Occidental, sedimentary rocks that show varying degrees of induration overlie the Tertiary volcanic rocks. Unit Ts designates coarse clastic deposits that are nearly totally lithified and were deposited in linear basins generally oriented northwest and bounded by a normal fault on at least one flank. These deposits are similar to basin-fill deposits formed during extension that have been described from the basin and range of Sonora (McDowell et al., 1997, and references therein). A prominent exposure of Ts in the western part of area 1 marks the eastern extent of the Sonoran Basin and Range. Similar deposits are widespread in the Chihuahua Basin and Range (areas 5–11). However, in that region, they can be difficult to distinguish from the younger unit QTal, which is used for unlithified sediments deposited in modern valleys. This difficulty arises because, until recent times, central Chihuahua has been characterized by internal drainage.

The student mappers have made the distinction between units Ts and QTal arbitrarily in some cases, and they did not always agree in contiguous areas (see map). Study of clastic deposits in the basin and range area of Chihuahua is a topic awaiting further attention.

### Pre-Tv Map Units

The volcanic belt of the Sierra Madre Occidental was emplaced over an older magmatic arc, at least on its western flank. Two map units (KTi and KTvs) have been used to delineate rocks related to this earlier (Laramide) arc. KTi consists of equigranular granodioritic plutons. One pluton in north-central area 1 has been dated at 63 Ma (sample 8). Another in central Chihuahua (area 9) is 60 Ma (sample 204). KTvs has been used for deposits of volcanic rocks and volcaniclastic sediments that also are associated with the Laramide arc. These are prominent in the eastern part of area 1. Older Mesozoic sedimentary units are designated by Ms. These are mostly middle Cretaceous limestones, but they include sedimentary rocks of Jurassic and Triassic age in the southwestern-most part of the map and adjacent to the pluton in the Sierra Magistral (area 9 on map). No exposures of older rocks are documented in the transect area. However, tuffs deposited near the Cascada de Basaseachic (easternmost part of area 1) contain lithic fragments of granitic gneiss that are as old as 1.6 Ga by U-Pb on zircon (Housh et al., 2003).

## STRUCTURE

### Calderas

Swanson and McDowell (1984) summarized existing evidence for calderas as sources for the ignimbrites within the Sierra Madre Occidental volcanic province. Although they adopted a liberal approach, including features identified only from satellite imagery, they could point to only twelve locations documented to be, or suggestive of, caldera features. In contrast, using the San Juan volcanic field as a scale, ~350 calderas would be necessary to produce a volcanic field of the dimensions of the Sierra Madre Occidental. Since that publication, there has been some progress in identifying caldera structures and other vent features that have produced ignimbrites, particularly in the southern Sierra Madre Occidental volcanic field (Ferrari et al., 2007). In the Copper Canyon region to the south and east of Tomochic, Swanson et al. (2006) have identified or suggested the existence of four additional caldera features.

Within the transect area, no evidence of caldera sources has been suggested since the 1984 publication. The caldera margins shown on the map represent a more conservative interpretation than that used by Swanson and McDowell (1984). They are drawn to indicate structural rather than topographic margins, and, with the exception of the Basaseachic caldera, retain the interpretations from the original student maps.

The well-described Tomochic caldera complex (Swanson and McDowell, 1985; Wark et al., 1990) can be considered a type locality for ignimbrite sources in the Sierra Madre Occidental volcanic field. The younger of the two structures (Tomochic caldera) is obvious in satellite imagery, and the moat fill, resurgent dome, and rhyolite domes and flows that mark the ring fracture are well preserved. However, the caldera structural boundary is concealed and can only be projected beneath the caldera fill. In addition, the erupted ignimbrite is not exposed anywhere within the caldera structure, so that the assignment of the erupted ignimbrite must be made by inference. Swanson and McDowell (1985) assigned the Rio Verde ignimbrite (Fig. 2A) to this caldera, although they noted that it comprises numerous (as many as 15) individual ash-flows, and that there seems to be an unusually long gap in time (ca. 1.5 Ma) between the dated Rio Verde eruption and K-Ar ages for the post-eruption caldera resurgence and fill. More recent and more precise chronology (Tables 5 and 6) has widened this gap to 2 Ma. It appears that the Tomochic caldera must be re-evaluated as a source for the Rio Verde ignimbrite.

The older component of the Tomochic caldera complex is the Las Varas caldera, source of the Vista ignimbrite (Fig. 2A; originally called the Aeropista ignimbrite by Swanson, 1977). This feature is centered to the north of the Tomochic caldera and is exposed at a deeper structural level, at which the interior is completely occupied by the intracaldera facies of the Vista ignimbrite (Wark et al., 1990). Although this fill may have lapped over the original structural margin, Wark et al. (1990) placed the caldera margin at the contact between intracaldera Vista and older units. Specific caldera-margin features are absent. Outside of this margin exposures of the outflow Vista ignimbrite are considerably thinner (Swanson, 1977; Kempter, 1986; Wark, 1989).

At the eastern margin of area 1, there is a clear fragment of a caldera boundary to the east of the falls (cascada) at Basaseachic (Fig. 1, locality C.B.). At the falls, a 300-m-thick section of the 28 Ma Cascada tuff dips gently eastward toward the unmapped area between area 1 and areas 2 and 3. That gap contains numerous domes and flows of rhyolite, some of which are also 28–29 Ma. At Basaseachic, the tuff is clearly intracaldera in nature and contains abundant fragments of older rocks, which include basement gneisses with ages of 1.6 Ga (Housh et al., 2003). Bockoven (1980) projected this caldera boundary using numerous exposures of small rhyolitic domes and small flows to mark the caldera margin. Exposures of volcanoclastic sediments interpreted as caldera-fill material occur within the south and southwest margins of this feature. Bockoven's (1980) interpretation proposed a resurgent caldera at least 40 km in diameter. On satellite images and regional-scale topographic maps the steep canyons of the Rios Condamena and Concheno appear to mark ~80% of the circular feature. On the other hand, much of the interior (and poorly accessible) "resurgent portion" is occupied by exposures assigned by Bockoven to the Late Cretaceous-early Tertiary lower volcanic complex, following earlier reconnaissance by Hovey (1905; 1907) and King (1939). Clearly, extensive exposures of older rock within a caldera structure present a problem for interpretation. Because distinction between "Laramide" and middle Tertiary intermediate composition volcanic rocks is lacking in this area, only the more obvious eastern portion of a caldera margin has been traced on the map. It is possible that rather than a single large structure, a number of smaller calderas are located within the southern and eastern portions of area 1.

Within the central Chihuahua area, complex post-volcanic faulting has made identification of caldera features difficult, even in areas of relatively detailed mapping. The Sierra Pastorias area (area 11) contains the most coherent volcanic exposures, and Megaw (1979) documented two calderas there. The Pastorias caldera (~20 km in diameter) is the northern and larger of the two. Although the northeastern third of its margin is buried by younger rocks, the remainder is well marked by a ring of small intrusive rhyolite exposures (unit Tv4i) that have erupted along the marginal fault(s), and by large blocks of middle Cretaceous limestone that have foundered into the caldera. Both of these features are shown on the map. Megaw assigned the Carretas tuff (Fig. 2C) to this caldera. To the south, Megaw mapped a smaller (10 km diameter) caldera that apparently was the source for his Nuevo tuff. Again, small intrusive rhyolite exposures mark part of the caldera margin.

**Other Features**

The Sierra Madre Occidental volcanic field was apparently emplaced in a neutral tectonic setting. The volcanic strata lack compressional deformation, which indicates emplacement after the completion of Laramide shortening. The timing of volcanism is older than that of regional extensional deformation. Within the central Sierra Madre Occidental, the rocks are essentially flat lying and little deformed. There are no major intervals of coarse gravels that would indicate the formation of graben structures related to extension. The only tectonic disruption in the central Sierra Madre Occidental is local sedimentation and deformation associated with the formation of calderas.

Late Tertiary deformation has infringed upon the original extent of the Sierra Madre Occidental volcanic field on both its east and west margins. East of Yécora (Fig. 1), a linear basin filled with clastic sediments (unit Ts) marks the eastern limit of the Sonoran Basin and Range province. A broad valley to the east of the Tomochic area (area 4) marks the separation of the unfaulted central Sierra Madre Occidental from the Chihuahua segment of the Mexican Basin and Range (Henry, and Aranda-Gómez, 1992). The volcanic rocks in the central Chihuahua portion of the map have been profoundly affected by this later tectonism. A grain of northwest-trending horsts is apparent throughout central Chihuahua (see map). However, the corresponding grabens have been partially filled with syn-tectonic coarse clastic material of unit Ts, and then flooded by debris of Late Tertiary (?) and Quaternary age (unit QTal). This post-faulting debris was deposited via internal drainage systems, and it remains unexcavated in much of central Chihuahua. Hence, the master range-bounding faults remain almost entirely concealed. Because volcanic strata in the horst blocks dip consistently and gently (10° to 20°) to the northeast and east, these master faults should be present along the southwest margins of the blocks. However, only where exposures of unit Ts adjoin the older rocks can the exact location of these faults be reasonably inferred. In many places the volcanic strata have been considerably disrupted by secondary structures related to these faults.

## SAMPLES

There are 223 samples for which analytical data have been obtained that are located on the transect map. They are plotted using consecutive numbers sorted by longitude from west to east. A master table (Appendix Table 2) lists the samples consecutively, and includes the original sample numbers, their coordinates in decimal degrees, and the type of analytical data available for each. The consecutive numbers are provided to facilitate inspection of the tables that contain the analytical data (Tables 3–8).

Most of the samples were collected from major units during the field studies for concurrent age and chemical measurements. Initially, locations were plotted on aerial photos or directly on 1:50000 topographic maps if available at that time. GPS measurements are not available for them, and the locations typically can be considered precise only to within 10s of meters. However, the original map unit and its stratigraphic position are well documented for each, and brief petrographic descriptions are given in the original theses and dissertations. The distribution of samples throughout the map is very uneven, primarily because extensive additional sampling has been undertaken in the Tomochic area. Sample groups were collected during all of the studies there, and Wark later collected another suite (those samples having a 90-XX notation) for an expanded investigation of the geochemistry of mafic lavas.

The analytical results are presented in subsequent sections with a minimum of discussion and interpretation. A more “in depth” treatment of the data is reserved for later publications.

## GEOCHEMISTRY

### Major-Element Analyses

Table 3 lists major-element oxide data for 175 samples. They are again ordered by longitude from west to east. Most of the sample powders were pulverized in tungsten carbide containers. Analyses completed concurrently with the mapping projects were made by wet chemical procedures at UT (method M1; see Table 3 footnotes), and include separate determinations of $H_2O^+$, $H_2O^-$, and $CO_2$, as well as $Fe^{+2}$ and $Fe^{+3}$ oxides. Later analyses were made by X-ray fluorescence (XRF), either at the Geoanalytical lab of Washington State University (WSU), or at University of Massachusetts, Amherst (methods M2 and M3). Because some samples were resubmitted for comprehensive trace element analyses by XRF, there is some duplication of the major-element determinations.

Normalized major-element compositions are shown on a plot of total alkalis against silica (Fig. 3A). This plot shows the dominance of both true rhyolites and basaltic andesites in the analyzed suite. There are only a sprinkling of intermediate composition rocks, and no true basalts. Samples from both the main Sierra Madre Occidental (in red) and from central Chihuahua (in green) are subalkaline for the most part. The latter group appears to have slightly higher alkali concentrations at a given silica value, but this distinction is made difficult for rhyolites because oxide totals are constrained to sum to 100%. A plot of total alkalis minus CaO versus silica (modified alkali-lime index of Frost et al., 2001) better emphasizes the contrast (Fig. 3B). Rhyolites from central Chihuahua (in green) are mostly alkali-calcic, whereas those from the Sierra Madre Occidental (in red) are mostly calc-alkalic. The regression lines calculated for the separate data sets are statistically different. Three analyses of ferroaugite rhyolites from central Chihuahua are included on this plot, but are not distinct from the others. However, the ferroaugite rhyolites are characterized by high FeO*/MgO (>40) relative to the other rhyolites from central Chihuahua (<22, with one exception).

### Trace-Element Chemistry

Table 4 lists trace-element data for 164 samples in order from west to east. A total of five combinations of lab and technique were used to obtain these data, which has resulted in duplication of some data for many of the samples. The table is organized so that the XRF data appear on the first three pages, followed by ICP and neutron activation results. During the course of the UT mapping projects, Bramson (1984) established XRF procedures for analyses of Rb, Sr, Y, Zr, and Nb concentrations (method T1). These data were acquired for all the samples analyzed at UT by wet chemistry. Method T2 refers to trace element determinations obtained from the WSU Geoanalytical lab by XRF and/or ICP-MS (in most cases XRF analyses were not requested for the samples analyzed previously by method T1). The investigation of Wark (1989) in the Tomochic area included expanded trace-element analyses obtained from Los Alamos National Laboratories (T5). For his subsequent examination of mafic lavas from the Tomochic region, he obtained XRF analyses from the University of Massachusetts, Amherst, (method T3) and neutron activation analyses from Oregon State University (method T4).

Figures 4A and 4B are trace-element variation diagrams for the rhyolites and basaltic andesites respectively, for which sufficiently complete analyses are available. In each plot, the profiles for main Sierra Madre Occidental and central Chihuahua samples are indicated by separate colors. Both compositional types from both areas display arc-type signatures. Further, the rhyolites show depletion of Ba and Sr, an expected result of feldspar fractionation. This is evident as well from prominent europium anomalies on REE plots (not shown).

## GEOCHRONOLOGY

### K-Ar Ages

There are 136 K-Ar ages listed in Table 5; these come from 113 samples, which are listed by longitude from west to east. Thirty of the samples are from the Tomochic area (areas 2, 3, and 4). Ninety of the ages have been published previously in the four

TABLE 3. MAJOR ELEMENT CHEMISTRY

| # | Sample | Unit | Method | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | FeO* | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | $H_2O^+$ | $H_2O^-$ | $CO_2$ | Total | LOI | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Tuml | M1 | 51.02 | 1.93 | 16.46 | 4.41 | 5.73 |  | 0.14 | 4.61 | 7.14 | 3.39 | 2.13 | 0.64 | 1.18 | 0.32 | 0.02 | 99.12 |  |  |
| 2 | 3-21-2 | Tv7 | M1 | 70.10 | 0.27 | 13.57 | 0.96 | 0.38 |  | 0.05 | 0.32 | 0.98 | 3.15 | 5.12 | 0.04 | 4.07 | 0.61 | 0.00 | 99.62 |  |  |
| 3 | 3-20-3 | Tuml | M1 | 58.32 | 1.20 | 16.51 | 2.93 | 3.97 |  | 0.11 | 2.62 | 5.45 | 3.67 | 2.54 | 0.42 | 0.52 | 0.76 | 0.08 | 99.10 |  |  |
| 6 | 3-20-1 | Tuml | M1 | 50.09 | 1.64 | 16.75 | 6.06 | 4.19 |  | 0.14 | 4.59 | 8.68 | 3.20 | 1.55 | 0.70 | 0.94 | 0.74 | 0.02 | 99.29 |  |  |
| 8 | Ma-1 | KTi | M1 | 58.71 | 0.82 | 16.41 | 2.38 | 3.78 |  | 0.09 | 3.01 | 5.98 | 3.16 | 2.71 | 0.17 | 1.13 | 0.23 | 1.01 | 99.59 |  |  |
| 10 | 12-11-13 | Tvu | M1 | 55.11 | 1.18 | 17.05 | 4.09 | 3.27 |  | 0.10 | 3.75 | 6.83 | 3.27 | 2.14 | 0.46 | 1.35 | 0.33 | 0.01 | 98.96 |  |  |
| 13 | 11-14-1 | Tvu | M1 | 63.09 | 0.61 | 15.23 | 4.42 | 0.26 |  | 0.07 | 1.62 | 4.31 | 3.98 | 2.11 | 0.17 | 2.30 | 1.66 | 0.01 | 99.84 |  |  |
| 15 | 10-23-5 | Tvu | M1 | 74.00 | 0.11 | 12.44 | 0.35 | 0.34 |  | 0.04 | 0.13 | 0.73 | 3.64 | 3.47 | 0.01 | 4.17 | 0.17 | 0.02 | 99.62 |  |  |
| 19 | BV5 | Tvu | M1 | 73.60 | 0.15 | 13.03 | 0.71 | 0.35 |  | 0.04 | 0.24 | 0.98 | 3.45 | 3.90 | 0.03 | 2.33 | 0.21 | 0.02 | 99.04 |  |  |
| 21 | 3-23-1 | Tuml | M1 | 61.55 | 0.92 | 16.46 | 2.87 | 2.35 |  | 0.04 | 1.68 | 4.83 | 4.00 | 2.79 | 0.34 | 1.69 | 0.30 | 0.03 | 99.85 |  |  |
| 22 | 10-25-2 | Tv4 | M1 | 75.77 | 0.22 | 13.35 | 0.88 | 0.20 |  | 0.02 | 0.27 | 1.00 | 3.54 | 4.22 | 0.02 | 0.35 | 0.27 | 0.08 | 100.23 |  |  |
| 25 | 90-29 | Tv2 | M3 | 61.81 | 0.81 | 16.59 |  |  | 5.69 | 0.11 | 2.65 | 5.50 | 3.79 | 2.54 | 0.19 |  |  |  | 99.68 |  |  |
| 28 | NV11 | Tv4 | M1 | 70.72 | 0.28 | 14.67 | 2.14 | 0.14 |  | 0.04 | 0.54 | 1.85 | 3.44 | 3.89 | 0.05 | 1.15 | 0.43 | 0.00 | 99.34 |  | 1 |
| 29 | NV01 | Tv4 | M1 | 73.64 | 0.33 | 13.89 | 1.91 | 0.12 |  | 0.07 | 0.33 | 1.09 | 3.99 | 4.04 | 0.06 | 0.94 | 0.07 | 0.00 | 100.48 |  | 1 |
| 31 | NV07 | Tv4 | M1 | 73.86 | 0.14 | 13.20 | 0.55 | 0.16 |  | 0.05 | 0.23 | 1.38 | 3.53 | 4.51 | 0.01 | 2.23 | 0.27 | 0.00 | 100.12 |  | 1 |
| 32 | 90-30 | Tv2 | M3 | 60.56 | 0.75 | 18.87 |  |  | 4.97 | 0.08 | 1.31 | 6.39 | 4.55 | 2.13 | 0.20 |  |  |  | 99.81 |  |  |
| 33 | O57 | Tv2 | M1 | 60.47 | 0.88 | 16.60 | 5.34 | 0.95 |  | 0.10 | 2.01 | 5.14 | 4.29 | 2.04 | 0.27 | 1.15 | 0.53 | 0.00 | 99.77 |  | 1 |
| 34 | O58 | Tv2 | M1 | 57.06 | 0.87 | 18.35 | 4.18 | 2.57 |  | 0.11 | 2.58 | 7.25 | 3.98 | 0.62 | 0.23 | 1.39 | 0.51 | 0.02 | 99.72 |  | 1 |
| 35 | O54 | Tuml | M1 | 56.75 | 1.07 | 17.43 | 4.21 | 3.32 |  | 0.11 | 3.18 | 6.62 | 3.26 | 1.66 | 0.29 | 1.75 | 0.49 | 0.03 | 100.17 |  | 1 |
| 36 | O72 | Tvu | M1 | 72.53 | 0.14 | 12.60 | 0.75 | 0.10 |  | 0.06 | 0.13 | 0.78 | 3.33 | 4.93 | 0.02 | 4.13 | 0.26 | 0.00 | 99.76 |  | 1 |
| 37 | O53 | Tuml | M1 | 65.59 | 0.67 | 15.13 | 1.94 | 2.41 |  | 0.08 | 1.46 | 3.91 | 3.15 | 3.77 | 0.21 | 1.70 | 0.17 | 0.00 | 100.19 |  | 1 |
| 38 | O52 | Tuml | M1 | 55.82 | 1.04 | 16.99 | 4.63 | 3.23 |  | 0.12 | 3.89 | 6.90 | 3.19 | 1.69 | 0.31 | 1.11 | 0.48 | 0.00 | 99.40 |  | 1 |
| 39 | C-21 | Tv4 | M1 | 70.58 | 0.41 | 15.20 | 2.85 | 0.34 |  | 0.04 | 0.62 | 2.39 | 3.97 | 2.72 | 0.12 | 0.74 | 0.22 | 0.00 | 100.20 |  |  |
| 40 | O48 | Tuml | M1 | 64.87 | 0.64 | 16.06 | 2.25 | 1.47 |  | 0.19 | 1.43 | 3.37 | 4.20 | 2.51 | 0.08 | 1.57 | 0.37 | 0.00 | 99.01 |  |  |
| 41 | O38 | Tuml | M1 | 66.98 | 0.53 | 15.86 | 2.25 | 0.56 |  | 0.09 | 0.65 | 2.42 | 4.07 | 3.45 | 0.14 | 2.18 | 0.37 | 0.00 | 99.55 |  | 1 |
| 42 | O39 | Tuml | M1 | 60.47 | 1.02 | 16.16 | 3.63 | 2.52 |  | 0.11 | 2.11 | 5.08 | 3.55 | 2.52 | 0.27 | 1.74 | 0.32 | 0.02 | 99.52 |  | 1 |
| 43 | O46 | Tv4 | M1 | 58.68 | 0.91 | 16.82 | 4.03 | 2.53 |  | 0.11 | 3.48 | 6.87 | 3.42 | 1.61 | 0.17 | 0.45 | 0.33 | 0.00 | 99.41 |  |  |
| 44 | 90-25 | Tv2 | M3 | 69.34 | 0.65 | 15.34 |  |  | 3.19 | 0.07 | 0.60 | 2.64 | 4.46 | 3.21 | 0.18 |  |  |  | 99.68 |  |  |
| 47 | 90-78 | Tv2 | M3 | 59.49 | 0.72 | 19.75 |  |  | 4.81 | 0.06 | 1.13 | 6.87 | 4.56 | 2.00 | 0.20 |  |  |  | 99.59 |  |  |
| 48 | 90-79 | Tv2 | M3 | 61.64 | 0.79 | 16.52 |  |  | 5.67 | 0.14 | 2.79 | 5.76 | 4.30 | 1.36 | 0.19 |  |  |  | 99.16 |  |  |
| 49 | 90-80 | Tv2 | M3 | 61.39 | 0.79 | 16.28 |  |  | 5.89 | 0.11 | 2.50 | 5.64 | 3.57 | 2.60 | 0.18 |  |  |  | 98.95 |  |  |
| 50 | O23 | Tv6 | M1 | 77.11 | 0.10 | 11.91 | 0.69 | 0.10 |  | 0.06 | 0.07 | 0.47 | 3.06 | 4.86 | 0.02 | 0.70 | 0.20 | 0.00 | 99.35 |  | 1 |
| 52 | P18A | Tv6 | M1 | 63.80 | 0.64 | 17.05 | 2.15 | 1.35 | 3.28 | 0.09 | 1.14 | 2.48 | 4.25 | 4.90 | 0.22 | 1.09 | 0.22 | 0.00 | 99.38 |  |  |
| 53 | N45 | Tv2 | M1 | 58.97 | 0.82 | 16.77 | 2.72 | 4.20 |  | 0.14 | 3.10 | 6.03 | 3.68 | 1.37 | 0.18 | 1.15 | 0.29 | 0.05 | 99.47 |  |  |

(*continued*)

TABLE 3. MAJOR ELEMENT CHEMISTRY (*continued*)

| # | Sample | Unit | Method | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | FeO* | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | $H_2O^+$ | $H_2O^-$ | $CO_2$ | Total | LOI | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | C-19 | Tv4 | M1 | 73.30 | 0.31 | 13.77 | 1.66 | 0.25 | | 0.05 | 0.56 | 1.83 | 3.42 | 3.76 | 0.06 | 0.92 | 0.64 | 0.29 | 100.82 | | |
| 55 | O18 | Tv6 | M1 | 62.02 | 0.81 | 16.16 | 2.77 | 1.72 | | 0.09 | 1.78 | 3.91 | 3.95 | 3.77 | 0.28 | 1.42 | 0.40 | 0.02 | 99.10 | | |
| 56 | O15 | Tv6 | M1 | 59.70 | 1.04 | 16.00 | 3.64 | 1.42 | | 0.11 | 1.79 | 3.79 | 3.73 | 4.30 | 0.46 | 1.65 | 1.41 | 0.00 | 99.04 | | |
| 59 | O13 | Tv6 | M1 | 58.46 | 1.28 | 16.01 | 3.99 | 3.20 | | 0.11 | 2.49 | 5.18 | 3.57 | 3.34 | 0.56 | 1.31 | 0.26 | 0.00 | 99.76 | | |
| 60 | 90-69 | Tv2 | M3 | 63.43 | 1.02 | 15.95 | | | 5.48 | 0.14 | 1.68 | 3.68 | 4.15 | 3.31 | 0.37 | | | | 99.21 | | |
| 62 | 90-73 | Tv2 | M3 | 58.10 | 1.12 | 17.36 | | | 7.12 | 0.11 | 2.63 | 6.04 | 4.32 | 2.12 | 0.28 | | | | 99.20 | | |
| 63 | O33 | Tv4 | M1 | 60.78 | 0.82 | 16.15 | 3.01 | 3.02 | | 0.10 | 3.42 | 5.93 | 3.33 | 2.15 | 0.16 | 0.65 | 0.39 | 0.02 | 99.93 | | |
| 64 | O-06 | Tv6 | M1 | 68.34 | 0.69 | 14.27 | 2.03 | 0.51 | | 0.08 | 0.83 | 1.79 | 2.99 | 6.74 | 0.10 | 0.42 | 0.26 | 0.00 | 99.05 | | |
| 65 | N-07 | Tv6 | M1 | 55.47 | 1.24 | 17.13 | 4.59 | 2.32 | | 0.08 | 3.45 | 6.75 | 3.84 | 2.41 | 0.43 | 1.10 | 0.83 | 0.00 | 99.63 | | |
| 66 | N-09 | Tv6 | M1 | 69.57 | 0.47 | 13.10 | 1.42 | 0.24 | | 0.04 | 2.10 | 1.03 | 3.01 | 5.96 | 0.05 | 0.92 | 1.06 | 0.12 | 99.09 | | |
| 67 | S-22 | Tv2 | M2 | 72.45 | 0.411 | 12.53 | | | 3.11 | 0.066 | 0.26 | 1.07 | 2.79 | 4.95 | 0.135 | | | | 97.77 | 0.61 | |
| 68 | 90-54 | Tv2 | M3 | 54.85 | 0.88 | 18.73 | | | 7.14 | 0.12 | 4.16 | 8.53 | 3.43 | 1.51 | 0.18 | | | | 99.53 | | |
| 69 | 90-53 | Tv2 | M3 | 53.37 | 0.90 | 19.38 | | | 7.54 | 0.14 | 4.11 | 9.11 | 3.30 | 1.29 | 0.18 | | | | 99.32 | | |
| 70 | 90-56 | Tv2 | M3 | 55.02 | 0.86 | 18.39 | | | 7.30 | 0.12 | 4.26 | 8.38 | 3.43 | 1.53 | 0.18 | | | | 99.47 | | |
| 72 | S-7 | Tv6 | M1 | 68.85 | 0.20 | 13.49 | 0.29 | 0.25 | | 0.06 | 0.24 | 1.25 | 3.53 | 2.71 | 0.00 | 7.22 | 1.13 | 0.04 | 99.26 | | |
| 74 | 90-52 | Tv2 | M3 | 54.06 | 0.76 | 16.73 | | | 7.65 | 0.11 | 5.65 | 10.07 | 2.99 | 1.26 | 0.15 | | | | 99.43 | | |
| 75 | 90-15 | Tv4 | M3 | 55.27 | 1.17 | 17.77 | | | 7.55 | 0.12 | 4.05 | 8.30 | 3.61 | 1.32 | 0.14 | | | | 99.30 | | |
| 76 | 90-14 | Tv4 | M3 | 54.83 | 1.17 | 17.87 | | | 7.60 | 0.12 | 4.40 | 8.58 | 3.43 | 1.17 | 0.14 | | | | 99.31 | | |
| 77 | 90-93 | Tv4 | M3 | 52.42 | 1.27 | 17.25 | | | 9.04 | 0.15 | 5.71 | 8.92 | 3.23 | 1.01 | 0.28 | | | | 99.28 | | |
| 78 | 90-12 | Tv4 | M3 | 56.35 | 1.07 | 18.02 | | | 6.78 | 0.11 | 4.01 | 7.87 | 3.63 | 1.49 | 0.17 | | | | 99.50 | | |
| 79 | N68 | Tv4 | M1 | 54.58 | 1.13 | 17.70 | 5.87 | 2.20 | | 0.12 | 4.23 | 7.98 | 3.15 | 1.37 | 0.14 | 0.66 | 0.68 | 0.04 | 99.85 | | 1 |
| 82 | O-04 | Tv3 | M1 | 70.88 | 0.24 | 13.26 | 1.17 | 0.26 | | 0.07 | 0.35 | 0.91 | 3.82 | 3.65 | 0.02 | 4.73 | 0.39 | 0.00 | 99.75 | | |
| 83 | 90-11 | Tv3 | M3 | 57.63 | 1.04 | 17.42 | | | 6.55 | 0.10 | 3.54 | 7.15 | 3.57 | 2.22 | 0.16 | | | | 99.38 | | |
| 84 | N53 | Tv4 | M1 | 61.16 | 0.69 | 16.58 | 4.71 | 1.00 | | 0.10 | 3.05 | 5.66 | 3.24 | 2.03 | 0.13 | 1.19 | 0.79 | 0.00 | 100.33 | | |
| 85 | 90-9 | Tv4 | M3 | 63.55 | 0.67 | 16.25 | | | 4.96 | 0.13 | 2.63 | 5.33 | 3.77 | 2.28 | 0.14 | | | | 99.71 | | |
| 88 | N70 | Tuml | M1 | 56.87 | 1.16 | 18.33 | 2.68 | 4.41 | | 0.12 | 3.56 | 6.67 | 3.46 | 1.71 | 0.39 | 0.60 | 0.15 | 0.00 | 100.11 | | 1 |
| 89 | 90-97 | Tuml | M3 | 54.68 | 0.88 | 18.64 | | | 7.14 | 0.12 | 4.14 | 8.55 | 3.43 | 1.52 | 0.18 | | | | 99.28 | | |
| 90 | 90-19 | Tv4 | M3 | 55.30 | 1.20 | 18.04 | | | 7.55 | 0.11 | 3.87 | 8.31 | 3.61 | 1.46 | 0.15 | | | | 99.60 | | |
| 91 | 90-85 | Tv4 | M3 | 55.90 | 1.18 | 17.84 | | | 7.24 | 0.12 | 4.11 | 7.80 | 3.43 | 1.45 | 0.18 | | | | 99.25 | | |
| 92 | 90-18 | Tv4 | M3 | 55.08 | 1.20 | 18.07 | | | 7.72 | 0.11 | 3.68 | 8.39 | 3.67 | 1.34 | 0.15 | | | | 99.41 | | |
| 93 | 90-60 | Tuml | M3 | 51.83 | 1.26 | 17.87 | | | 8.54 | 0.13 | 5.84 | 9.12 | 3.31 | 1.06 | 0.26 | | | | 99.22 | | |
| 94 | 90-6 | Tv4 | M3 | 56.16 | 1.04 | 17.35 | | | 7.31 | 0.12 | 4.03 | 8.09 | 3.48 | 1.70 | 0.20 | | | | 99.48 | | |
| 95 | S-3 | Tv3 | M2 | 70.50 | 0.273 | 13.13 | | | 1.29 | 0.083 | 0.45 | 1.03 | 4.29 | 3.38 | 0.044 | | | | 94.47 | 5.06 | |
| 96 | 90-46 | Tv2 | M3 | 69.39 | 0.59 | 15.39 | | | 3.17 | 0.10 | 0.65 | 2.46 | 4.48 | 3.33 | 0.20 | | | | 99.76 | | |

(*continued*)

TABLE 3. MAJOR ELEMENT CHEMISTRY (*continued*)

| # | Sample | Unit | Method | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | FeO* | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | $H_2O^+$ | $H_2O^-$ | $CO_2$ | Total | LOI | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | 90-63 | Tuml | M3 | 59.77 | 1.33 | 15.56 | | | 7.76 | 0.16 | 2.54 | 5.50 | 4.06 | 2.49 | 0.38 | | | | 99.55 | | |
| 98 | 90-64 | Tuml | M3 | 59.60 | 1.32 | 15.37 | | | 7.69 | 0.15 | 2.47 | 5.44 | 3.90 | 2.48 | 0.38 | | | | 98.80 | | |
| 99 | 90-4 | Tv4 | M3 | 61.71 | 0.73 | 16.54 | | | 5.42 | 0.14 | 3.60 | 5.62 | 3.61 | 2.01 | 0.14 | | | | 99.52 | | |
| 100 | 90-99 | Tuml | M3 | 57.30 | 1.17 | 18.02 | | | 6.82 | 0.12 | 3.30 | 6.94 | 4.01 | 1.52 | 0.38 | | | | 99.58 | | |
| 101 | 86-40 | Tv4 | M1 | 74.19 | 0.13 | 12.52 | 1.04 | 0.10 | | 0.06 | 0.14 | 0.60 | 3.21 | 4.73 | 0.11 | 2.73 | 0.12 | 0.08 | 99.76 | | |
| 105 | 90-101 | Tuml | M3 | 57.23 | 1.16 | 17.89 | | | 6.71 | 0.12 | 3.29 | 6.90 | 3.88 | 1.53 | 0.38 | | | | 99.09 | | |
| 106 | 90-21 | Tuml | M3 | 61.63 | 0.80 | 16.40 | | | 5.91 | 0.11 | 2.49 | 5.67 | 3.59 | 2.63 | 0.19 | | | | 99.42 | | |
| 107 | 90-100 | Tuml | M3 | 57.45 | 1.15 | 17.86 | | | 6.68 | 0.11 | 3.20 | 6.84 | 4.03 | 1.57 | 0.38 | | | | 99.27 | | |
| 108 | 90-20 | Tuml | M3 | 50.71 | 1.39 | 17.21 | | | 9.81 | 0.20 | 5.51 | 9.15 | 3.31 | 1.00 | 0.28 | | | | 98.57 | | |
| 110 | 90-2 | Tv4 | M3 | 56.05 | 1.17 | 17.80 | | | 7.17 | 0.13 | 4.02 | 7.90 | 3.42 | 1.42 | 0.20 | | | | 99.28 | | |
| 111 | 90-106 | Tv4 | M3 | 55.26 | 1.28 | 18.80 | | | 7.70 | 0.13 | 3.96 | 8.14 | 3.09 | 0.81 | 0.16 | | | | 99.33 | | |
| 113 | S-6 | Tv3 | M2 | 68.31 | 0.484 | 13.61 | | | 2.38 | 0.088 | 0.90 | 1.94 | 3.49 | 4.19 | 0.136 | | | | 95.54 | 2.92 | |
| 113 | S-6 | Tv3 | M1 | 69.26 | 0.33 | 14.31 | 1.01 | 0.48 | | 0.05 | 0.52 | 2.72 | 3.69 | 4.07 | 0.07 | 2.63 | 0.20 | 0.00 | 99.34 | | |
| 114 | N55 | Tv5 | M1 | 65.97 | 0.62 | 14.14 | 2.00 | 1.04 | | 0.09 | 0.83 | 2.38 | 3.96 | 2.98 | 0.12 | 4.69 | 0.71 | 0.00 | 99.53 | | 1 |
| 115 | N57 | Tv5 | M1 | 69.04 | 0.38 | 13.65 | 1.26 | 0.63 | | 0.07 | 0.46 | 1.31 | 4.61 | 2.85 | 0.04 | 5.07 | 0.52 | 0.00 | 99.89 | | 1 |
| 116 | 90-110 | Tuml | M3 | 55.74 | 1.17 | 17.92 | | | 7.24 | 0.11 | 4.08 | 7.49 | 3.65 | 1.60 | 0.39 | | | | 99.39 | | |
| 118 | N60 | Tv5 | M1 | 70.11 | 0.28 | 13.31 | 1.39 | 0.26 | | 0.07 | 0.40 | 0.81 | 3.95 | 4.25 | 0.02 | 3.88 | 0.48 | 0.02 | 99.23 | | 1 |
| 120 | S-32 | Tv6 | M2 | 73.49 | 0.249 | 13.26 | | | 1.70 | 0.064 | 0.27 | 1.14 | 3.40 | 5.08 | 0.042 | | | | 98.70 | 0.47 | |
| 120 | S-32 | Tv6 | M3 | 74.19 | 0.13 | 12.52 | | | 1.03 | 0.06 | 0.14 | 0.60 | 3.21 | 4.73 | 0.11 | | | | 96.72 | | |
| 120 | S-32 | Tv6 | M1 | 75.44 | 0.21 | 12.96 | 0.09 | 0.43 | | 0.04 | 0.17 | 1.08 | 3.28 | 5.01 | 0.01 | 0.26 | 0.18 | 0.00 | 99.16 | | |
| 121 | N71 | Tuml | M1 | 55.18 | 0.96 | 18.38 | 3.96 | 3.57 | | 0.12 | 3.55 | 7.45 | 3.35 | 1.81 | 0.31 | 1.01 | 0.22 | 0.17 | 100.04 | | 1 |
| 122 | S-23 | Tv6 | M2 | 64.20 | 0.704 | 14.95 | | | 3.37 | 0.098 | 0.99 | 2.99 | 3.77 | 3.03 | 0.291 | | | | 94.40 | 4.78 | |
| 123 | 90-112 | Tuml | M3 | 55.54 | 0.99 | 18.70 | | | 7.20 | 0.12 | 3.57 | 7.70 | 3.58 | 1.41 | 0.32 | | | | 99.13 | | |
| 124 | 90-115 | Tuml | M3 | 55.93 | 1.14 | 18.22 | | | 7.23 | 0.11 | 3.52 | 7.48 | 3.86 | 1.54 | 0.38 | | | | 99.41 | | |
| 126 | 90-117 | Tuml | M3 | 55.16 | 1.07 | 18.80 | | | 7.35 | 0.09 | 3.60 | 7.59 | 3.81 | 1.33 | 0.31 | | | | 99.11 | | |
| 128 | C-13 | Tuml? | M1 | 54.55 | 1.08 | 18.09 | 4.41 | 3.25 | | 0.11 | 4.50 | 8.22 | 3.51 | 1.30 | 0.37 | 0.71 | 0.21 | 0.01 | 100.32 | | |
| 129 | C-17B | Tv5 | M1 | 72.53 | 0.41 | 14.47 | 0.20 | 1.76 | | 0.06 | 0.23 | 0.67 | 4.33 | 4.27 | 0.04 | 0.35 | 0.17 | 0.02 | 99.51 | | |
| 130 | C-14B | Tv4 | M1 | 71.22 | 0.31 | 15.07 | 0.16 | 2.22 | | 0.04 | 0.68 | 2.11 | 3.78 | 3.12 | 0.09 | 0.63 | 0.49 | 0.00 | 99.92 | | |
| 135 | D77A | KTi | M1 | 77.07 | 0.15 | 12.69 | 0.62 | 0.20 | | 0.04 | 0.18 | 0.46 | 3.65 | 4.77 | 0.04 | 0.35 | 0.17 | 0.00 | 100.39 | | |
| 136 | D86A | KTi | M1 | 53.52 | 1.13 | 16.12 | 2.95 | 4.05 | | 0.11 | 3.99 | 6.52 | 3.50 | 1.51 | 0.36 | 3.12 | 0.22 | 2.43 | 99.94 | | |
| 140 | D69C | Tv5 | M1 | 70.50 | 0.49 | 13.62 | 1.20 | 0.69 | | 0.07 | 0.37 | 1.02 | 4.34 | 3.85 | 0.07 | 3.52 | 0.18 | 0.00 | 99.92 | | |
| 142 | D70B | Tv4 | M1 | 69.40 | 0.49 | 13.20 | 1.52 | 0.72 | | 0.07 | 0.47 | 1.33 | 4.35 | 2.80 | 0.09 | 4.64 | 0.36 | 0.01 | 99.45 | | |
| 145 | D84A | Tv5 | M1 | 72.01 | 0.32 | 12.86 | 1.01 | 0.45 | | 0.06 | 0.27 | 0.93 | 3.79 | 4.11 | 1.08 | 3.69 | 0.47 | 0.02 | 100.07 | | |

(*continued*)

TABLE 3. MAJOR ELEMENT CHEMISTRY (*continued*)

| # | Sample | Unit | Method | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | FeO* | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | $H_2O^+$ | $H_2O^-$ | $CO_2$ | Total | LOI | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 146 | D70D | Tuml | M1 | 53.60 | 1.31 | 17.40 | 3.95 | 4.14 | | 0.12 | 4.28 | 8.00 | 3.44 | 1.59 | 0.56 | 0.51 | 0.15 | 0.02 | 99.07 | | |
| 146 | D70D | Tuml | M2 | 53.59 | 1.351 | 17.25 | | | 7.95 | 0.133 | 4.25 | 8.05 | 3.59 | 1.62 | 0.466 | | | | 98.25 | | |
| 149 | D76B | Tfr | M1 | 77.50 | 0.12 | 11.37 | 1.74 | 0.10 | | 0.01 | 0.05 | 0.28 | 3.46 | 4.68 | 0.02 | 0.22 | 0.14 | 0.01 | 99.70 | | |
| 150 | D76A | Tuml | M1 | 52.80 | 1.45 | 17.69 | 3.67 | 4.98 | | 0.10 | 4.62 | 8.05 | 3.47 | 1.32 | 0.44 | 0.69 | 0.23 | 0.00 | 99.51 | | |
| 152 | D75A | Tv4 | M1 | 67.60 | 0.43 | 15.41 | 1.44 | 0.72 | | 0.04 | 0.49 | 2.16 | 4.30 | 3.64 | 0.09 | 3.15 | 0.09 | 0.00 | 99.56 | | |
| 154 | D85B | Tv5 | M1 | 66.89 | 0.56 | 15.12 | 2.67 | 0.35 | | 0.09 | 1.00 | 3.09 | 4.33 | 3.37 | 0.23 | 0.71 | 0.41 | 0.24 | 99.06 | | |
| 155 | J-140 | Tfr | M1 | 75.84 | 0.16 | 11.85 | 1.94 | 0.15 | | 0.03 | 0.05 | 0.04 | 3.71 | 5.23 | 0.02 | 0.29 | 0.09 | 0.00 | 99.40 | | |
| 155 | J-140 | Tfr | M2 | 75.18 | 0.156 | 11.55 | | | 1.91 | 0.030 | 0.03 | 0.09 | 3.74 | 5.12 | 0.025 | | | | 97.84 | | |
| 157 | D53D | Tuml | M1 | 54.60 | 0.94 | 16.55 | 3.66 | 4.22 | | 0.13 | 5.35 | 8.33 | 3.11 | 1.53 | 0.33 | 0.47 | 0.15 | 0.02 | 99.39 | | |
| 159 | J-256 | Tv5 | M1 | 69.36 | 0.56 | 14.51 | 3.27 | 0.16 | | 0.08 | 0.36 | 0.96 | 5.02 | 4.66 | 0.11 | 0.53 | 0.21 | 0.02 | 99.80 | | |
| 160 | J-369 | Tv5 | M1 | 72.42 | 0.24 | 12.85 | 0.87 | 0.37 | | 0.04 | 0.23 | 0.84 | 3.34 | 4.81 | 0.02 | 3.48 | 0.26 | 0.00 | 99.78 | | |
| 160 | J-369 | Tv5 | M2 | 71.19 | 0.237 | 12.59 | | | 1.15 | 0.047 | 0.22 | 0.92 | 3.32 | 4.78 | 0.035 | | | | 94.49 | | |
| 163 | J-375 | Tv3 | M1 | 71.71 | 0.19 | 12.61 | 0.74 | 0.35 | | 0.06 | 0.26 | 0.70 | 4.82 | 2.78 | 0.02 | 5.27 | 0.70 | 0.00 | 100.07 | | |
| 163 | J-375 | Tv3 | M2 | 70.66 | 0.179 | 12.31 | | | 0.91 | 0.071 | 0.11 | 0.70 | 4.75 | 2.75 | 0.015 | | | | 92.47 | | |
| 168 | J-399 | Tv6 | M1 | 72.18 | 0.23 | 12.90 | 0.87 | 0.40 | | 0.12 | 0.12 | 0.84 | 2.80 | 5.32 | 0.03 | 3.67 | 0.16 | 0.00 | 99.70 | | |
| 170 | W-200 | Tv5 | M1 | 77.05 | 0.18 | 12.12 | 1.04 | 0.10 | | 0.05 | 0.09 | 0.07 | 3.84 | 4.86 | 0.02 | 0.36 | 0.18 | 0.00 | 99.96 | | |
| 170 | W-200 | Tv5 | M2 | 76.31 | 0.168 | 11.71 | | | 0.97 | 0.064 | 0.07 | 0.13 | 3.76 | 4.82 | 0.018 | | | | 98.02 | | |
| 172 | W-176 | Tuml | M1 | 55.12 | 0.70 | 14.59 | 4.43 | 3.28 | | 0.12 | 6.84 | 8.55 | 2.68 | 1.36 | 0.14 | 0.63 | 0.19 | 0.00 | 99.04 | | |
| 172 | W-176 | Tuml | M2 | 55.37 | 0.671 | 14.36 | | | 7.40 | 0.148 | 6.97 | 9.07 | 2.71 | 1.40 | 0.142 | | | | 98.24 | | |
| 173 | I-151 | Tv4 | M1 | 72.85 | 0.38 | 13.55 | 1.76 | 0.15 | | 0.07 | 0.17 | 0.42 | 3.22 | 5.60 | 0.07 | 0.78 | 0.19 | 0.00 | 99.21 | | |
| 174 | I-112 | Tv4 | M1 | 61.20 | 0.86 | 15.86 | 4.82 | 0.52 | | 0.07 | 2.59 | 4.89 | 3.69 | 2.50 | 0.30 | 1.10 | 0.75 | 0.00 | 99.15 | | |
| 175 | I-521 | Tv4 | M1 | 74.96 | 0.16 | 12.97 | 1.65 | 0.09 | | 0.03 | 0.15 | 0.15 | 3.89 | 4.23 | 0.03 | 0.50 | 0.40 | 0.00 | 99.21 | | |
| 175 | I-521 | Tv4 | M2 | 73.79 | 0.162 | 12.35 | | | 1.56 | 0.033 | 0.13 | 0.16 | 3.91 | 4.76 | 0.045 | | | | 96.90 | | |
| 176 | I-532 | Tuml | M1 | 60.65 | 0.98 | 16.09 | 4.23 | 1.61 | | 0.09 | 2.63 | 5.19 | 5.08 | 2.37 | 0.33 | 0.85 | 0.63 | 0.00 | 100.73 | | |
| 176 | I-532 | Tuml | M2 | 60.38 | 0.974 | 15.86 | | | 5.44 | 0.096 | 2.65 | 5.11 | 3.89 | 2.42 | 0.342 | | | | 97.16 | | |
| 177 | I-44 | Tv4 | M1 | 72.16 | 0.18 | 12.35 | 0.97 | 0.63 | | 0.07 | 0.10 | 0.39 | 3.33 | 5.32 | 0.03 | 3.97 | 0.10 | 0.00 | 99.60 | | |
| 177 | I-44 | Tv4 | M2 | 71.68 | 0.160 | 12.15 | | | 1.52 | 0.070 | 0.07 | 0.41 | 3.23 | 5.40 | 0.017 | | | | 94.70 | | |
| 178 | DZ-29 | Tv6 | M1 | 66.60 | 0.57 | 15.51 | 2.83 | 0.18 | | 0.07 | 0.50 | 1.65 | 4.42 | 3.84 | 0.22 | 1.64 | 0.53 | 0.00 | 98.56 | | |
| 179 | DZ-2 | Tv6 | M1 | 71.24 | 0.31 | 14.51 | 1.74 | 0.12 | | 0.12 | 0.20 | 0.76 | 4.70 | 4.41 | 0.04 | 1.17 | 0.13 | 0.05 | 99.50 | | |
| 179 | DZ-2 | Tv6 | M2 | 71.05 | 0.333 | 14.28 | | | 1.66 | 0.125 | 0.18 | 0.77 | 4.52 | 4.40 | 0.026 | | | | 97.35 | | |
| 181 | I-133 | Tuml | M1 | 50.94 | 1.38 | 16.97 | 5.14 | 3.99 | | 0.14 | 5.49 | 7.98 | 3.22 | 1.39 | 0.51 | 1.36 | 0.48 | 0.10 | 99.09 | | |
| 181 | I-133 | Tuml | M2 | 51.60 | 1.436 | 16.87 | | | 8.56 | 0.143 | 5.44 | 8.37 | 3.12 | 1.42 | 0.498 | | | | 97.46 | | |
| 184 | I-478 | Tv4 | M1 | 72.62 | 0.32 | 13.72 | 1.87 | 0.08 | | 0.06 | 0.17 | 0.81 | 3.73 | 5.14 | 0.07 | 0.57 | 0.24 | 0.13 | 99.53 | | |
| 185 | I-164 | Tv4 | M1 | 74.09 | 0.22 | 13.75 | 1.05 | 0.16 | | 0.03 | 0.09 | 0.48 | 4.56 | 4.12 | 0.08 | 0.28 | 0.16 | 0.00 | 99.07 | | |
| 186 | HF-1 | Tuml | M1 | 66.87 | 0.61 | 16.87 | 2.52 | 0.42 | | 0.09 | 0.31 | 1.58 | 6.02 | 3.55 | 0.21 | 0.43 | 0.32 | 0.00 | 99.80 | | |

(*continued*)

TABLE 3. MAJOR ELEMENT CHEMISTRY (*continued*)

| # | Sample | Unit | Method | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | FeO* | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | $H_2O^+$ | $H_2O^-$ | $CO_2$ | Total | LOI | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 187 | VG-7B | Tv4 | M1 | 77.59 | 0.16 | 12.07 | 0.90 | 0.30 | | 0.09 | 0.06 | 0.14 | 3.55 | 5.07 | 0.04 | 0.31 | 0.08 | 0.00 | 100.36 | | |
| 187 | VG-7B | Tv4 | M2 | 76.66 | 0.172 | 11.72 | | | 1.06 | 0.086 | 0.03 | 0.15 | 3.41 | 5.01 | 0.022 | | | | 98.33 | | |
| 190 | PLM | Tuml | M1 | 54.90 | 1.66 | 17.16 | 3.01 | 5.26 | | 0.14 | 2.49 | 6.29 | 4.70 | 2.59 | 0.70 | 0.92 | 0.37 | 0.00 | 100.19 | | |
| 190 | PLM | Tuml | M2 | 54.51 | 1.678 | 16.79 | | | 7.91 | 0.148 | 2.47 | 6.19 | 3.90 | 2.65 | 0.703 | | | | 96.95 | | |
| 191 | HW-1 | Tuml | M1 | 56.91 | 1.18 | 17.69 | 5.93 | 0.82 | | 0.18 | 1.05 | 3.91 | 5.82 | 3.31 | 0.71 | 1.10 | 0.47 | 0.00 | 99.08 | | |
| 192 | Ni-102 | Tv6 | M1 | 69.69 | 0.50 | 15.01 | 2.36 | 0.20 | | 0.08 | 0.30 | 1.47 | 5.28 | 3.95 | 0.13 | 0.37 | 0.10 | 0.02 | 99.46 | | |
| 192 | Ni-102 | Tv6 | M2 | 68.66 | 0.539 | 14.64 | | | 2.33 | 0.079 | 0.29 | 1.51 | 5.01 | 3.85 | 0.122 | | | | 97.03 | | |
| 193 | J-CH | Tv4 | M1 | 76.65 | 0.17 | 11.79 | 2.13 | 0.07 | | 0.05 | 0.05 | 0.15 | 3.33 | 5.06 | 0.03 | 0.24 | 0.16 | 0.00 | 99.86 | | |
| 194 | PC-1 | Tuml | M1 | 56.14 | 1.21 | 17.58 | 6.51 | 0.30 | | 0.20 | 0.93 | 3.87 | 5.75 | 3.52 | 0.65 | 1.21 | 0.47 | 0.00 | 98.34 | | |
| 194 | PC-1 | Tuml | M2 | 56.73 | 1.261 | 17.68 | | | 6.30 | 0.199 | 0.96 | 3.79 | 5.64 | 3.51 | 0.632 | | | | 96.70 | | |
| 195 | Ni-30 | Tv6 | M1 | 72.93 | 0.32 | 14.23 | 1.53 | 0.22 | | 0.06 | 0.20 | 0.81 | 3.93 | 5.24 | 0.06 | 0.35 | 0.09 | 0.00 | 99.97 | | |
| 199 | ER-51 | Tv4 | M1 | 67.82 | 0.24 | 13.62 | 0.95 | 0.36 | | 0.08 | 0.52 | 0.78 | 4.94 | 3.03 | 0.03 | 5.97 | 0.97 | 0.00 | 99.31 | | |
| 200 | ER-13B | Tv4 | M1 | 67.60 | 0.24 | 13.72 | 0.88 | 0.40 | | 0.08 | 0.71 | 0.92 | 4.99 | 2.89 | 0.04 | 6.02 | 1.14 | 0.00 | 99.63 | | |
| 201 | CG-BL | Tv2 | M1 | 74.18 | 0.18 | 12.93 | 1.03 | 0.13 | | 0.03 | 0.36 | 0.48 | 3.10 | 5.09 | 0.05 | 0.91 | 1.06 | 0.00 | 99.53 | | |
| 202 | NJ-5 | Tv4 | M1 | 73.55 | 0.14 | 11.92 | 0.98 | 0.28 | | 0.07 | 0.25 | 0.61 | 4.18 | 3.12 | 0.03 | 3.88 | 0.43 | 0.00 | 99.44 | | |
| 202 | NJ-5 | Tv4 | M2 | 73.49 | 0.166 | 11.54 | | | 1.15 | 0.076 | 0.24 | 0.63 | 4.17 | 3.08 | 0.020 | | | | 94.55 | | |
| 203 | Monz | KTi | M1 | 65.05 | 0.48 | 16.41 | 2.04 | 1.07 | | 0.05 | 2.05 | 4.70 | 4.29 | 2.37 | 0.14 | 0.56 | 0.19 | 0.02 | 99.42 | | |
| 205 | Z-VIT | Tv4 | M1 | 65.20 | 0.11 | 11.67 | 1.00 | 0.21 | | 0.09 | 0.38 | 5.23 | 2.81 | 3.03 | 0.04 | 5.66 | 1.67 | 2.50 | 99.60 | | |
| 207 | RED | Tv1 | M1 | 71.32 | 0.48 | 14.55 | 1.91 | 0.58 | | 0.02 | 0.47 | 1.40 | 3.26 | 5.54 | 0.13 | 0.45 | 0.15 | 0.00 | 100.26 | | |
| 207 | RED | Tv1 | M2 | 70.24 | 0.469 | 14.27 | | | 2.20 | 0.021 | 0.46 | 1.52 | 3.24 | 5.56 | 0.117 | | | | 98.10 | | |
| 208 | RP | Tv4 | M1 | 74.78 | 0.18 | 12.90 | 1.09 | 0.24 | | 0.05 | 0.17 | 0.68 | 3.44 | 4.92 | 0.13 | 0.58 | 0.15 | 0.00 | 99.31 | | |
| 211 | ECI | Tv4 | M1 | 76.60 | 0.11 | 11.70 | 1.28 | 0.00 | | 0.11 | 0.18 | 0.13 | 3.26 | 5.02 | 0.01 | 0.49 | 0.77 | 0.21 | 99.67 | | 2 |
| 212 | ECD | Tuml | M1 | 53.90 | 1.63 | 15.61 | 2.87 | 6.09 | | 0.13 | 4.59 | 7.00 | 3.39 | 2.11 | 0.94 | 0.62 | 0.46 | 0.10 | 99.44 | | 2 |
| 213 | 4RSRB | Tuml | M1 | 55.39 | 1.21 | 16.64 | 3.17 | 4.43 | | 0.11 | 4.39 | 7.22 | 3.58 | 1.92 | 0.42 | 0.61 | 0.13 | 0.05 | 99.26 | | 2 |
| 213 | 4RSRB | Tuml | M2 | 55.76 | 1.228 | 16.89 | | | 7.26 | 0.120 | 4.44 | 7.69 | 3.67 | 1.95 | 0.361 | | | | 99.37 | | |
| 214 | RND1 | Tv4 | M1 | 73.04 | 0.34 | 13.77 | 1.68 | 0.10 | | 0.04 | 0.29 | 0.53 | 4.01 | 4.90 | 0.08 | 0.34 | 0.77 | 0.00 | 99.89 | | 2 |
| 215 | TTV | Tv4 | M1 | 69.68 | 0.34 | 13.96 | 1.18 | 0.52 | | 0.09 | 0.33 | 0.97 | 4.85 | 3.38 | 0.07 | 3.69 | 0.35 | 0.00 | 99.41 | | 2 |
| 217 | 4EN-1 | Tv4 | M1 | 74.03 | 0.16 | 13.12 | 1.10 | 0.16 | | 0.06 | 0.36 | 0.30 | 3.69 | 4.82 | 0.05 | 0.83 | 1.05 | 0.00 | 99.73 | | 2 |
| 218 | 4MPB | Tuml | M1 | 54.20 | 1.62 | 17.43 | 3.73 | 4.26 | | 0.11 | 3.91 | 7.65 | 3.72 | 1.30 | 0.49 | 0.49 | 0.11 | 0.10 | 99.12 | | 2 |
| 219 | PMES1 | Tv4 | M1 | 77.31 | 0.19 | 12.33 | 1.08 | 0.10 | | 0.04 | 0.13 | 0.54 | 3.28 | 5.21 | 0.04 | 0.10 | 0.14 | 0.02 | 100.51 | | 2 |
| 220 | CLLD | Tv4 | M1 | 76.25 | 0.04 | 12.73 | 1.22 | 0.05 | | 0.14 | 0.14 | 0.55 | 3.61 | 4.98 | 0.01 | 0.41 | 0.35 | 0.01 | 100.49 | | 2 |
| 221 | OWLD | Tv4 | M1 | 69.09 | 0.50 | 15.50 | 2.39 | 0.15 | | 0.04 | 0.35 | 1.23 | 4.61 | 4.75 | 0.14 | 0.42 | 0.38 | 0.00 | 99.55 | | 2 |
| 222 | 4BASI | Tuml | M1 | 54.94 | 1.26 | 15.70 | 6.50 | 1.79 | | 0.14 | 5.46 | 6.89 | 3.38 | 1.61 | 0.73 | 0.45 | 0.65 | 0.10 | 99.60 | | 2 |
| 223 | XYZB | Tuml | M1 | 55.48 | 1.20 | 15.70 | 4.70 | 3.12 | | 0.12 | 5.49 | 6.77 | 3.52 | 2.04 | 0.62 | 0.69 | 0.43 | 0.03 | 99.91 | | 2 |

*Note:* References (Ref.): 1—Wark (1991); 2—Megaw and McDowell (1983). M1—analyses at University of Texas, Austin, using standard wet chemical techiniques. M2—analyses at Washington State University Geoanalytical Lab by X-ray Fluorescence. M3—analyses at University of Massachusetts, Amherst, by X-ray Fluorescence. LOI—loss on ignition.

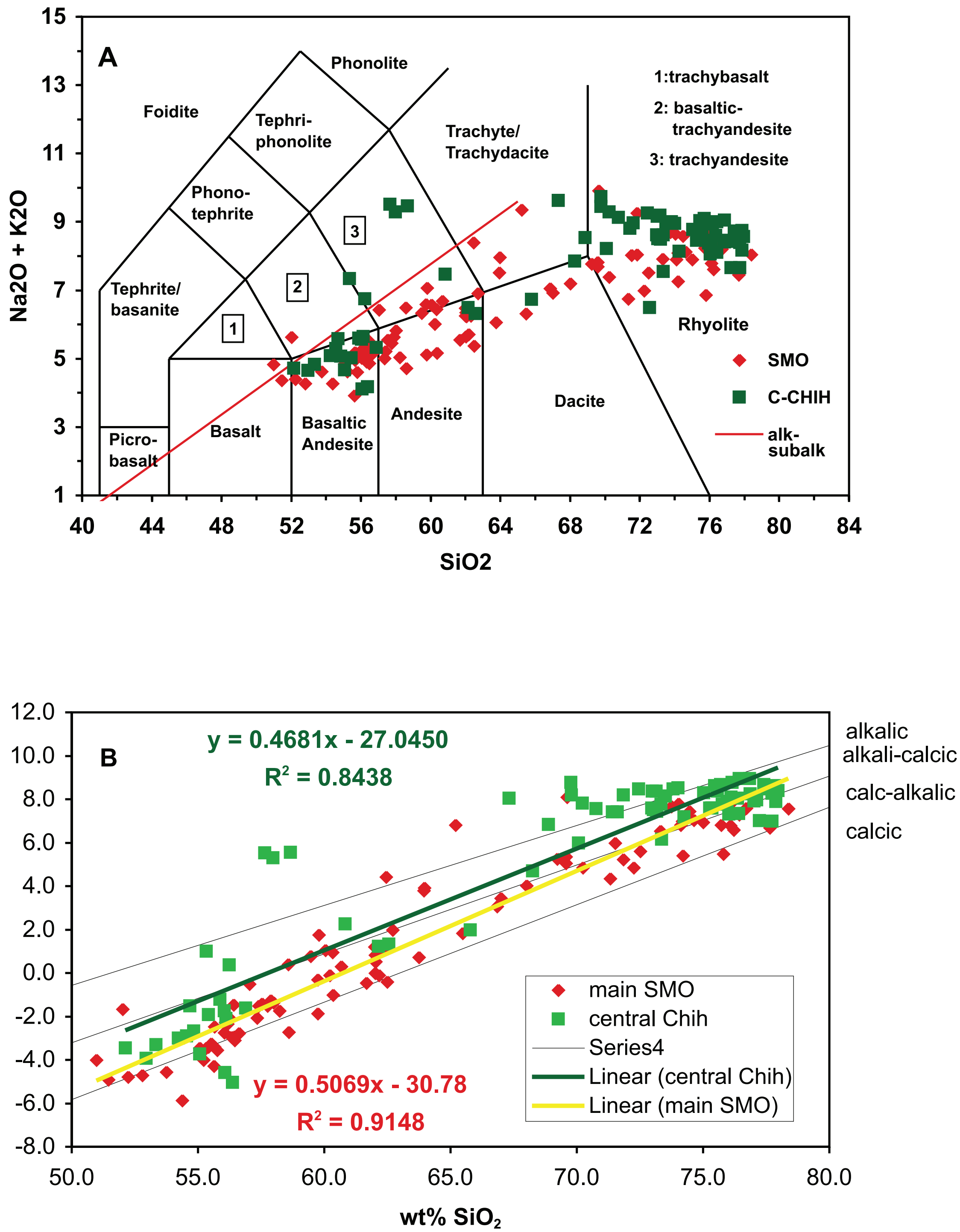



Figure 3. (A) Plot of total alkalis against silica (LeBas et al., 1986) for analyzed rocks from the Sierra Madre Occidental (in red) and central Chihuahua (in green). The alkaline-subalkaline boundary is after MacDonald (1968). (B) A plot of total alkalis minus CaO against silica, including the classification boundaries proposed by Frost et al. (2001) as thin black lines. Analyses from the Sierra Madre Occidental are in red and those from central Chihuahua are in green. Linear regression lines calculated separately through the Sierra Madre Occidental data (yellow line) and the central Chihuahua data (green line) are shown with their statistical parameters.

TABLE 4. TRACE ELEMENT DATA

| # | Sample | Unit | Tech. | Ref. | Rb | Sr | Y | Zr | Nb | Ni | V | Ba | Zn | Cu | Pb | Ga | Sc | Cr | Th | Nd | U | La | Ce |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Tuml | T1,T2 | | 34 | 664 | 26 | 253 | 30 | | | | | | | | | | | | | | |
| 2 | 3-21-2 | Tv7 | T1,T2 | | 213 | 148 | 21 | 223 | 21 | | | | | | | | | | | | | | |
| 3 | 3-20-3 | Tuml | T1 | | 64 | 583 | 24 | 264 | 26 | | | | | | | | | | | | | | |
| 6 | 3-20-1 | Tuml | T1,T2 | | 23 | 765 | 25 | 183 | 28 | | | | | | | | | | | | | | |
| 8 | Ma-1 | KTi | T1 | | 103 | 481 | 24 | 158 | 20 | | | | | | | | | | | | | | |
| 10 | 12-11-3 | Tvu | T1 | | 43 | 660 | 22 | 288 | 40 | | | | | | | | | | | | | | |
| 13 | 11-14-1 | Tvu | T1 | | 53 | 584 | 16 | 142 | 9 | | | | | | | | | | | | | | |
| 15 | 10-23-5 | Tvu | T1,T2 | | 100 | 145 | 13 | 89 | 14 | | | | | | | | | | | | | | |
| 19 | BV5 | Tvu | T1,T2 | | 110 | 172 | 9 | 82 | 13 | | | | | | | | | | | | | | |
| 21 | 3-23-1 | Tuml | T1,T2 | | 133 | 463 | 26 | 272 | 25 | | | | | | | | | | | | | | |
| 22 | 10-25-2 | Tv4 | T1 | | 187 | 102 | 21 | 83 | 14 | | | | | | | | | | | | | | |
| 25 | 90-29 | Tv2 | T3 | | 58 | 542 | 21 | 158 | 6 | 7 | 97 | 804 | 82 | | 9 | 20 | | 7 | 4 | | 1 | 15 | 43 |
| 28 | NV11 | Tv4 | T1,T5 | 1 | 146 | 212 | 19 | 109 | 10 | | | | 40 | | | | | | | | | | |
| 29 | NV01 | Tv4 | T1,T5 | 1 | 140 | 152 | 31 | 244 | 12 | | | | 8 | | | | | | | | | | |
| 31 | NV07 | Tv4 | T1,T5 | 1 | 228 | 114 | 21 | 81 | 7 | | | | 33 | | | | | | | | | | |
| 32 | 90-30 | Tv2 | T3 | | 63 | 504 | 23 | 172 | 7 | 8 | 95 | 840 | 61 | | 10 | 20 | | 5 | 5 | | 1 | 20 | 46 |
| 33 | O57 | Tv2 | T1,T5 | 1 | 73 | 468 | 27 | 207 | 12 | | | | 126 | | | | | | | | | | |
| 34 | O58 | Tv2 | T1 | 1 | 57 | 590 | 19 | 163 | 11 | | | | | | | | | | | | | | |
| 35 | O54 | Tuml | T1 | 1 | 60 | 605 | 20 | 181 | 13 | | | | | | | | | | | | | | |
| 36 | O72 | Tvu | T1,T5 | 1 | 193 | 77 | 27 | 115 | 7 | | | | 62 | | | | | | | | | | |
| 37 | O53 | Tuml | T1,T5 | 1 | 156 | 382 | 36 | 225 | 12 | | | | 108 | | | | | | | | | | |
| 38 | O52 | Tuml | T1 | 1 | 65 | 599 | 23 | 182 | 14 | | | | | | | | | | | | | | |
| 39 | C-21 | Tv4 | T1 | | 104 | 275 | 16 | 152 | 9 | | | | | | | | | | | | | | |
| 40 | O48 | Tuml | T5 | | | | | | | | | | 152 | | | | | | | | | | |
| 41 | O38 | Tuml | T1,T5 | 1 | 112 | 358 | 32 | 259 | 14 | | | | 87 | | | | | | | | | | |
| 42 | O39 | Tuml | T1,T5 | 1 | 89 | 522 | 29 | 200 | 16 | | | | 160 | | | | | | | | | | |
| 44 | 90-25 | Tv2 | T3,T4 | | 102 | 296 | 32 | 295 | 10 | 7 | 48 | 1125 | 76 | | 17 | 16 | | 2 | 10 | | 3 | 32 | 59 |
| 47 | 90-78 | Tv2 | T3,T4 | | 112 | 337 | 27 | 189 | 9 | 14 | 112 | 726 | 77 | | 13 | 17 | | 11 | 14 | | 5 | 19 | 52 |
| 48 | 90-79 | Tv2 | T3,T4 | | 166 | 353 | 26 | 198 | 9 | 14 | 117 | 755 | 72 | | 12 | 17 | | 11 | 14 | | 5 | 21 | 53 |
| 49 | 90-80 | Tv2 | T3,T4 | | 118 | 345 | 27 | 199 | 9 | 14 | 120 | 714 | 69 | | 14 | 18 | | 15 | 13 | | 5 | 22 | 50 |
| 50 | O23 | Tv6 | T1,T5 | 1 | 225 | 7 | 35 | 115 | 12 | | | | 4 | | | | | | | | | | |
| 53 | N45 | Tv2 | T1 | | 107 | 392 | 30 | 175 | 10 | | | | | | | | | | | | | | |
| 54 | C-19 | Tv4 | T1 | | 143 | 162 | 18 | 113 | 14 | | | | | | | | | | | | | | |
| 55 | O18 | Tv6 | T1,T5 | | 158 | 370 | 9 | 317 | 13 | | | | 84 | | | | | | | | | | |
| 56 | O15 | Tv6 | T1 | | 69 | 446 | 29 | 504 | 18 | | | | | | | | | | | | | | |
| 59 | O13 | Tv6 | T1,T5 | | 110 | 496 | 39 | 364 | 16 | | | | 159 | | | | | | | | | | |
| 60 | 90-69 | Tv2 | T3,T4 | | 122 | 326 | 41 | 303 | 14 | 3 | 65 | 955 | 85 | | 16 | 17 | | 0 | 14 | | 4 | 39 | 73 |
| 62 | 90-73 | Tv2 | T3,T4 | | 75 | 444 | 25 | 170 | 8 | 6 | 146 | 712 | 89 | | 9 | 20 | | 0 | 7 | | 3 | 15 | 41 |
| 63 | O33 | Tv4 | T1 | | 73 | 518 | 22 | 134 | 16 | | | | | | | | | | | | | | |
| 64 | O-06 | Tv6 | T1,T5 | | 162 | 148 | 26 | 548 | 11 | | | | 45 | | | | | | | | | | |
| 65 | N-07 | Tv6 | T1,T5 | | 61 | 572 | 23 | 276 | 14 | | | | 123 | | | | | | | | | | |
| 66 | N-09 | Tv6 | T1,T5 | | 239 | 102 | 22 | 599 | 10 | | | | | | | | | | | | | | |
| 67 | S-22 | Tv2 | T2 | | 178 | 284 | 52 | 249 | 12.7 | 6 | 36 | 1052 | 84 | 56 | 18 | 18 | 11 | 109 | 14 | 60 | 6 | 61 | 91 |
| 67 | S-22 | Tv2 | T2 | | 180 | 128 | 20 | 199 | 8.9 | 32 | 123 | 635 | 75 | 78 | 16 | 14 | 7 | 2437 | 13 | 23 | 5 | 29 | 48 |
| 68 | 90-54 | Tv2 | T3 | | 33 | 564 | 23 | 125 | 6 | 7 | 190 | 525 | 80 | | 8 | 19 | | 30 | 5 | | 2 | 15 | 35 |
| 69 | 90-53 | Tv2 | T3,T4 | | 31 | 592 | 24 | 129 | 6 | 6 | 194 | 574 | 90 | | 9 | 20 | | 31 | 5 | | 2 | 14 | 34 |
| 70 | 90-56 | Tv2 | T3,T4 | | 42 | 554 | 23 | 123 | 6 | 6 | 167 | 514 | 79 | | 10 | 19 | | 26 | 5 | | 2 | 15 | 34 |
| 72 | S-7 | Tv6 | T1 | | 529 | 246 | 55 | 195 | 13 | | | | | | | | | | | | | | |
| 74 | 90-52 | Tv2 | T3 | | 35 | 490 | 20 | 106 | 4 | 36 | 215 | 450 | 84 | | 8 | 17 | | 306 | 4 | | 2 | 9 | 29 |
| 75 | 90-15 | Tv4 | T3,T4 | | 29 | 790 | 14 | 88 | 3 | 11 | 170 | 521 | 78 | | 5 | 19 | | 33 | 3 | | 1 | 0 | 25 |
| 76 | 90-14 | Tv4 | T3,T4 | | 19 | 812 | 14 | 91 | 3 | 14 | 182 | 513 | 83 | | 7 | 19 | | 34 | 2 | | 0 | 2 | 23 |
| 77 | 90-93 | Tv4 | T3 | | 14 | 567 | 20 | 117 | 4 | 62 | 180 | 620 | 97 | | 6 | 19 | | 138 | 3 | | 1 | 12 | 29 |
| 78 | 90-12 | Tv4 | T3,T4 | | 29 | 865 | 14 | 102 | 2 | 12 | 154 | 577 | 83 | | 7 | 20 | | 30 | 4 | | 2 | 16 | 31 |
| 79 | N68 | Tv4 | T1,T5 | 1 | 39 | 816 | 22 | 136 | 18 | | | | | | | | | | | | | | |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| # | Sample | Unit | Tech. | Ref. | Rb | Sr | Y | Zr | Nb | Ni | V | Ba | Zn | Cu | Pb | Ga | Sc | Cr | Th | Nd | U | La | Ce |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | N66 | Tv4 | T5 | | | | | | | | | | 140 | | | | | | | | | | |
| 82 | O-04 | Tv3 | T1,T5 | | 241 | 157 | 45 | 227 | 10 | | | | 118 | | | | | | | | | | |
| 83 | 90-11 | Tv3 | T3,T4 | | 56 | 748 | 14 | 104 | 4 | 16 | 148 | 648 | 76 | | 10 | 20 | | 26 | 4 | | 1 | 16 | 30 |
| 84 | N53 | Tv4 | T1,T5 | | 71 | 565 | 20 | 136 | 10 | | | | 73 | | | | | | | | | | |
| 85 | 90-9 | Tv4 | T3,T4 | | 74 | 509 | 19 | 119 | 6 | 18 | 146 | 769 | 70 | | 10 | 18 | | 38 | 8 | | 2 | 21 | 39 |
| 86 | N65 | Tv4 | T5 | | | | | | | | | | 11 | | | | | | | | | | |
| 87 | W-60 | Tv4 | T5 | | | | | | | | | | | | | | | | | | | | |
| 88 | N70 | Tuml | T1,T5 | 1 | 41 | 802 | 20 | 164 | 17 | | | | 148 | | | | | | | | | | |
| 89 | 90-97 | Tuml | T3,T4 | | 40 | 619 | 24 | 192 | 9 | 32 | 175 | 798 | 111 | | 10 | 19 | | 64 | 3 | | 1 | 29 | 58 |
| 90 | 90-19 | Tv4 | T3,T4 | | 26 | 785 | 14 | 92 | 2 | 11 | 171 | 502 | 81 | | 6 | 21 | | 31 | 2 | | 1 | 7 | 22 |
| 91 | 90-85 | Tv4 | T3,T4 | | 45 | 1008 | 14 | 102 | 3 | 14 | 154 | 531 | 75 | | 7 | 20 | | 24 | 4 | | 1 | 16 | 35 |
| 92 | 90-18 | Tv4 | T3,T4 | | 29 | 793 | 14 | 90 | 2 | 15 | 165 | 524 | 76 | | 5 | 20 | | 31 | 2 | | 1 | 5 | 22 |
| 93 | 90-60 | Tuml | T3,T4 | | 18 | 646 | 18 | 102 | 4 | 54 | 191 | 492 | 92 | | 7 | 18 | | 88 | 3 | | 1 | 14 | 27 |
| 94 | 90-6 | Tv4 | T3,T4 | | 45 | 545 | 16 | 106 | 4 | 15 | 272 | 650 | 82 | | 10 | 20 | | 103 | 5 | | 1 | 12 | 28 |
| 95 | S-3 | Tv3 | T2 | | 251 | 122 | 38 | 246 | 13.1 | 5 | 7 | 1052 | 85 | 72 | 22 | 15 | 5 | 103 | 18 | 41 | 7 | 39 | 81 |
| 96 | 90-46 | Tv2 | T3,T4 | | 120 | 262 | 32 | 195 | 9 | 2 | 26 | 971 | 72 | | 15 | 17 | | 0 | 14 | | 5 | 29 | 58 |
| 97 | 90-63 | Tuml | T3,T4 | | 92 | 391 | 37 | 211 | 11 | 6 | 158 | 866 | 99 | | 12 | 18 | | 2 | 9 | | 4 | 24 | 55 |
| 98 | 90-64 | Tuml | T3,T4 | | 92 | 389 | 37 | 209 | 11 | 7 | 153 | 842 | 102 | | 16 | 19 | | 1 | 9 | | 4 | 25 | 54 |
| 99 | 90-4 | Tv4 | T3,T4 | | 63 | 549 | 16 | 114 | 5 | 21 | 122 | 703 | 74 | | 9 | 17 | | 42 | 7 | | 2 | 13 | 36 |
| 100 | 90-99 | Tuml | T3,T4 | | 29 | 791 | 18 | 136 | 7 | 16 | 127 | 761 | 100 | | 9 | 20 | | 29 | 2 | | 1 | 18 | 40 |
| 101 | 86-40 | Tv4 | T1,T5 | 1 | 300 | 32 | 29 | 93 | 8 | | | | 33 | | | | | | | | | | |
| 102 | N58 | Tv5 | T1,T5 | 1 | 145 | 136 | 38 | 264 | 12 | | | | 137 | | | | | | | | | | |
| 103 | N62 | Tv5 | T5 | 1 | | | | | | | | | 96 | | | | | | | | | | |
| 105 | 90-101 | Tuml | T3,T4 | | 29 | 788 | 19 | 140 | 7 | 17 | 129 | 759 | 102 | | 10 | 19 | | 32 | 2 | | 1 | 18 | 47 |
| 106 | 90-21 | Tuml | T3,T4 | | 33 | 798 | 18 | 139 | 7 | 16 | 130 | 743 | 100 | | 9 | 20 | | 29 | 2 | | 1 | 16 | 40 |
| 107 | 90-100 | Tuml | T3,T4 | | 31 | 777 | 19 | 137 | 7 | 17 | 128 | 746 | 99 | | 9 | 19 | | 28 | 3 | | 1 | 20 | 44 |
| 108 | 90-20 | Tuml | T3,T4 | | 14 | 509 | 27 | 142 | 8 | 19 | 252 | 450 | 95 | | 5 | 20 | | 12 | 0 | | 1 | 15 | 33 |
| 110 | 90-2 | Tv4 | T3,T4 | | 30 | 1012 | 15 | 100 | 4 | 16 | 153 | 630 | 81 | | 8 | 20 | | 26 | 4 | | 1 | 15 | 31 |
| 111 | 90-106 | Tv4 | T3,T4 | | 18 | 1385 | 15 | 99 | 3 | 13 | 154 | 602 | 75 | | 7 | 21 | | 30 | 3 | | 2 | 17 | 29 |
| 113 | S-6 | Tv3 | T2 | | 175 | 245 | 38 | 297 | 14.7 | 8 | 37 | 1057 | 71 | 39 | 22 | 17 | 10 | 226 | 16 | 35 | 6 | 38 | 77 |
| 114 | N55 | Tv5 | T1,T5 | 1 | 206 | 335 | 42 | 245 | 13 | | | | 11 | | | | | | | | | | |
| 115 | N57 | Tv5 | T1,T5 | 1 | 216 | 125 | 41 | 299 | 11 | | | | 83 | | | | | | | | | | |
| 116 | 90-110 | Tuml | T3,T4 | | 26 | 942 | 16 | 137 | 6 | 25 | 143 | 641 | 107 | | 9 | 21 | | 48 | 2 | | 1 | 22 | 42 |
| 118 | N60 | Tv5 | T1,T5 | 1 | 287 | 68 | 45 | 260 | 10 | | | | 122 | | | | | | | | | | |
| 120 | S-32 | Tv6 | T1,T2,T5 | | 244 | 74 | 34 | 133 | 7 | | | | 36 | | | | | | | | | | |
| 121 | N71 | Tuml | T1,T5 | 1 | 40 | 955 | 18 | 132 | 16 | | | | 121 | | | | | | | | | | |
| 122 | S-23 | Tv6 | T2 | | 228 | 124 | 28 | 175 | 11.6 | 25 | 73 | 903 | 53 | 102 | 24 | 14 | 4 | 1718 | 27 | 31 | 11 | 39 | 82 |
| 123 | 90-112 | Tuml | T3,T4 | | 21 | 987 | 16 | 95 | 4 | 15 | 154 | 482 | 94 | | 10 | 21 | | 9 | 3 | | 1 | 19 | 38 |
| 124 | 90-115 | Tuml | T3,T4 | | 17 | 944 | 16 | 125 | 5 | 24 | 145 | 724 | 103 | | 10 | 21 | | 39 | 3 | | 1 | 19 | 38 |
| 126 | 90-117 | Tuml | T3,T4 | | 18 | 970 | 13 | 89 | 4 | 16 | 145 | 484 | 93 | | 8 | 22 | | 18 | 2 | | 1 | 14 | 33 |
| 128 | C-13 | Tuml? | T1 | | 24 | 923 | 17 | 128 | 8 | | | | | | | | | | | | | | |
| 129 | C-17B | Tv5 | T1 | | 178 | 105 | 46 | 332 | 19 | | | | | | | | | | | | | | |
| 130 | C-14B | Tv4 | T1 | | 127 | 247 | 17 | 121 | 9 | | | | | | | | | | | | | | |
| 135 | D77A | KTi | T1 | | 244 | 59 | 34 | 99 | 12 | | | | | | | | | | | | | | |
| 136 | D86A | KTi | T1 | | 35 | 611 | 19 | 165 | 16 | | | | | | | | | | | | | | |
| 140 | D69C | Tv5 | T1,T2 | | 186 | 118 | 53 | 337 | 23 | | | | | | | | | | | | | | |
| 142 | D70B | Tv4 | T1 | | 190 | 172 | 35 | 264 | 24 | | | | | | | | | | | | | | |
| 145 | D84A | Tv5 | T1 | | 221 | 106 | 33 | 222 | 17 | | | | | | | | | | | | | | |
| 146 | D70D | Tuml | T1,T2 | | 27 | 636 | 28 | 203 | 19 | | | | | | | | | | | | | | |
| 149 | D76B | Tfr | T1,T2 | | 326 | 6 | 88 | 429 | 55 | | | | | | | | | | | | | | |
| 150 | D76A | Tuml | T1 | | 22 | 762 | 18 | 177 | 13 | | | | | | | | | | | | | | |
| 152 | D75A | Tv4 | T1,T2 | | 183 | 234 | 27 | 343 | 25 | | | | | | | | | | | | | | |
| 154 | D85B | Tv5 | T1 | | 117 | 305 | 24 | 199 | 11 | | | | | | | | | | | | | | |
| 155 | J-140 | Tfr | T1 | | 342 | 15 | 70 | 500 | 55 | | | | | | | | | | | | | | |
| 155 | J-140 | Tfr | T2 | | 335 | 9 | 71 | 466 | 44.0 | 6 | 33 | 55 | 127 | 6 | 42 | 26 | 2 | 2 | 35 | 60 | 11 | 63 | 128 |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| # | Sample | Unit | Tech. | Ref. | Rb | Sr | Y | Zr | Nb | Ni | V | Ba | Zn | Cu | Pb | Ga | Sc | Cr | Th | Nd | U | La | Ce |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | D53D | Tuml | T1,T2 | | 18 | 679 | 23 | 144 | 9 | | | | | | | | | | | | | | |
| 159 | J-256 | Tv5 | T1 | | 150 | 141 | 40 | 386 | 22 | | | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | T1 | | 228 | 124 | 18 | 176 | 7 | | | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | T2 | | 231 | 132 | 19 | 170 | 10.6 | 5 | 10 | 999 | 32 | 4 | 18 | 15 | 2 | 1 | 20 | 21 | 7 | 32 | 58 |
| 163 | J-375 | Tv3 | T1 | | 183 | 103 | 18 | 183 | 9 | | | | | | | | | | | | | | |
| 163 | J-375 | Tv3 | T2 | | 207 | 131 | 38 | 200 | 19.2 | 4 | 2 | 211 | 61 | 2 | 26 | 17 | 5 | 2 | 20 | 39 | 10 | 38 | 81 |
| 168 | J-399 | Tv6 | T1 | | 208 | 126 | 39 | 217 | 27 | | | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | T1 | | 214 | 7 | 37 | 222 | 23 | | | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | T2 | | 215 | 4 | 35 | 225 | 19.9 | 6 | 5 | 40 | 52 | 2 | 18 | 19 | 3 | 2 | 20 | 28 | 6 | 36 | 64 |
| 172 | W-176 | Tuml | T1 | | 38 | 471 | 13 | 90 | 0 | | | | | | | | | | | | | | |
| 172 | W-176 | Tuml | T2 | | 34 | 487 | 20 | 110 | 3.1 | 31 | 197 | 424 | 77 | 39 | 6 | 16 | 29 | 307 | 2 | 16 | 2 | 9 | 29 |
| 173 | I-151 | Tv4 | T1 | | 259 | 74 | 37 | 255 | 12 | | | | | | | | | | | | | | |
| 174 | I-112 | Tv4 | T1 | | 83 | 560 | 23 | 184 | 19 | | | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | T1 | | 198 | 22 | 34 | 277 | 16 | | | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | T2 | | 194 | 10 | 33 | 289 | 16.4 | 5 | 1 | 656 | 70 | 2 | 21 | 17 | 7 | 1 | 21 | 44 | 8 | 44 | 86 |
| 176 | I-532 | Tuml | T1 | | 85 | 580 | 18 | 179 | 16 | | | | | | | | | | | | | | |
| 176 | I-532 | Tuml | T2 | | 75 | 600 | 20 | 178 | 7.9 | 28 | 120 | 974 | 75 | 14 | 13 | 19 | 11 | 69 | 6 | 26 | 5 | 26 | 52 |
| 177 | I-44 | Tv4 | T1 | | 199 | 12 | 37 | 253 | 9 | | | | | | | | | | | | | | |
| 177 | I-44 | Tv4 | T2 | | 200 | 9 | 42 | 288 | 16.7 | 5 | 1 | 636 | 71 | 1 | 21 | 18 | 7 | 2 | 21 | 43 | 7 | 46 | 90 |
| 178 | DZ-29 | Tv6 | T1 | | 128 | 314 | 34 | 325 | 15 | | | | | | | | | | | | | | |
| 179 | DZ-2 | Tv6 | T2 | | 121 | 136 | 43.7 | 369 | 19.3 | 8 | 6 | 1731 | 81 | 1 | 20 | 19 | 5 | 2 | 12 | 57 | 4 | 51 | 100 |
| 181 | I-133 | Tuml | T1 | | 31 | 822 | 0 | 178 | 191 | | | | | | | | | | | | | | |
| 181 | I-133 | Tuml | T2 | | 32 | 848 | 24 | 167 | 7.0 | 66 | 200 | 728 | 96 | 39 | 10 | 20 | 20 | 80 | 3 | 27 | 2 | 27 | 58 |
| 184 | I-478 | Tv4 | T1 | | 193 | 84 | 74 | 251 | 24 | | | | | | | | | | | | | | |
| 186 | HF-1 | Tuml | T1 | | 122 | 316 | 31 | 346 | 19 | | | | | | | | | | | | | | |
| 187 | VG-7B | Tv4 | T2 | | 200 | 13 | 39 | 223 | 14.2 | 6 | 7 | 231 | 56 | 2 | 19 | 17 | 4 | 2 | 17 | 30 | 5 | 33 | 71 |
| 190 | PLM | Tuml | T1 | | 72 | 502 | 33 | 356 | 23 | | | | | | | | | | | | | | |
| 190 | PLM | Tuml | T2 | | 66 | 496 | 41 | 364 | 17.6 | 17 | 137 | 1267 | 123 | 26 | 17 | 21 | 14 | 17 | 7 | 50 | 3 | 44 | 92 |
| 191 | HW-1 | Tuml | T1 | | 95 | 606 | 35 | 202 | 26 | | | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | T1 | | 124 | 181 | 41 | 422 | 15 | | | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | T2 | | 118 | 185 | 43 | 431 | 15.1 | 5 | 32 | 1097 | 46 | 2 | 16 | 19 | 7 | 2 | 8 | 40 | 1 | 40 | 75 |
| 193 | J-CH | Tv4 | T1 | | 213 | 24 | 52 | 336 | 18 | | | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | T1 | | 96 | 591 | 40 | 483 | 24 | | | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | T2 | | 92 | 607 | 45 | 464 | 13.2 | 7 | 60 | 1478 | 127 | 2 | 18 | 23 | 6 | 3 | 7 | 44 | 5 | 43 | 79 |
| 195 | Ni-30 | Tv6 | T1 | | 174 | 124 | 27 | 232 | 16 | | | | | | | | | | | | | | |
| 199 | ER-51 | Tv4 | T1 | | 273 | 72 | 45 | 269 | 17 | | | | | | | | | | | | | | |
| 201 | CG-BL | Tv2 | T1 | | 245 | 48 | 36 | 165 | 21 | | | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | T1 | | 215 | 130 | 39 | 225 | 13 | | | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | T2 | | 216 | 133 | 35 | 243 | 14.9 | 6 | 4 | 42 | 73 | 1 | 25 | 21 | 4 | 4 | 16 | 34 | 4 | 31 | 69 |
| 203 | Monz | KTi | T1 | | 287 | 426 | 48 | 253 | 38 | | | | | | | | | | | | | | |
| 205 | Z-VIT | Tv4 | T1 | | 287 | 426 | 48 | 253 | 38 | | | | | | | | | | | | | | |
| 207 | RED | Tv1 | T2 | | 283 | 227 | 20 | 258 | 16.0 | 12 | 39 | 814 | 36 | 7 | 26 | 19 | 5 | 184 | 36 | 31 | 11 | 44 | 84 |
| 208 | RP | Tv4 | T1 | | 210 | 42 | 39 | 152 | 20 | | | | | | | | | | | | | | |
| 211 | EC1 | Tv4 | T1,T2 | | 350 | 14 | 70 | 325 | 40 | | | | | | | | | | | | | | |
| 212 | ECD | Tuml | T1 | | 41 | 652 | 37 | 351 | 29 | | | | | | | | | | | | | | |
| 213 | 4RSRB | Tuml | T1 | | 56 | 742 | 23 | 228 | 16 | | | | | | | | | | | | | | |
| 214 | RND1 | Tv4 | T1,T2 | | 150 | 56 | 48 | 343 | 24 | | | | | | | | | | | | | | |
| 215 | TTV | Tv4 | T1,T2 | | 194 | 207 | 43 | 352 | 35 | | | | | | | | | | | | | | |
| 217 | 4EN1 | Tv4 | T1 | | 175 | 35 | 58 | 433 | 40 | | | | | | | | | | | | | | |
| 218 | 4MPB | Tuml | T1 | | 27 | 767 | 20 | 124 | 14 | | | | | | | | | | | | | | |
| 219 | PMES1 | Tv4 | T1 | | 303 | 38 | 46 | 178 | 22 | | | | | | | | | | | | | | |
| 220 | CLLD | Tv4 | T1,T2 | | 206 | 37 | 38 | 157 | 25 | | | | | | | | | | | | | | |
| 221 | OWLD | Tv4 | T1,T2 | | 137 | 161 | 41 | 471 | 26 | | | | | | | | | | | | | | |
| 222 | 4BAS1 | Tuml | T1 | | 32 | 653 | 26 | 277 | 24 | | | | | | | | | | | | | | |
| 223 | XYZB | Tuml | T1 | | 44 | 625 | 29 | 289 | 34 | | | | | | | | | | | | | | |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| | SAMPLE | UNIT | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Ba | Th | Nb | Y | Hf | Ta | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Tuml | 35.26 | 67.91 | 8.24 | 34.82 | 7.93 | 2.39 | 7.31 | 1.12 | 6.50 | 1.27 | 3.30 | 0.47 | 2.81 | 0.44 | 912 | 2.83 | 25.71 | 35.50 | 5.68 | 1.78 | 0.85 |
| 2 | 3-21-2 | Tv7 | 44.82 | 74.05 | 8.30 | 29.66 | 5.80 | 1.02 | 4.65 | 0.76 | 4.63 | 0.93 | 2.66 | 0.41 | 2.71 | 0.44 | 1339 | 13.21 | 14.23 | 27.26 | 5.96 | 1.45 | 3.67 |
| 3 | 3-20-3 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 6 | 3-20-1 | Tuml | 38.06 | 73.80 | 9.19 | 39.36 | 8.71 | 2.65 | 7.62 | 1.09 | 6.22 | 1.17 | 3.03 | 0.42 | 2.50 | 0.39 | 913 | 4.60 | 12.03 | 32.22 | 4.17 | 0.88 | 1.04 |
| 8 | Ma-1 | KTi | | | | | | | | | | | | | | | | | | | | | |
| 10 | 12-11-3 | Tvu | | | | | | | | | | | | | | | | | | | | | |
| 13 | 11-14-1 | Tvu | | | | | | | | | | | | | | | | | | | | | |
| 15 | 10-23-5 | Tvu | 27.68 | 46.90 | 4.58 | 15.24 | 2.66 | 0.49 | 1.95 | 0.30 | 1.73 | 0.33 | 0.95 | 0.15 | 1.03 | 0.17 | 1225 | 11.56 | 8.32 | 10.51 | 2.73 | 1.54 | 2.97 |
| 19 | BV5 | Tvu | 25.60 | 44.32 | 4.39 | 14.98 | 2.75 | 0.53 | 2.13 | 0.33 | 1.94 | 0.38 | 1.06 | 0.16 | 1.09 | 0.18 | 1204 | 11.14 | 8.37 | 11.60 | 2.74 | 1.34 | 2.98 |
| 21 | 3-23-1 | Tuml | 36.88 | 72.17 | 8.53 | 35.01 | 7.93 | 1.88 | 6.92 | 1.04 | 5.93 | 1.13 | 2.99 | 0.43 | 2.63 | 0.41 | 1032 | 8.54 | 11.83 | 31.33 | 6.65 | 1.11 | 2.30 |
| 22 | 10-25-2 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 25 | 90-29 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 28 | NV11 | Tv4 | 41.7 | 57.0 | | | 4.29 | 0.94 | | 0.60 | | | | | 2.31 | 0.36 | 928 | 17.6 | | | 3.85 | 0.88 | 3.85 |
| 29 | NV01 | Tv4 | 45.8 | 85.1 | | | 7.58 | 1.51 | | 0.94 | | | | | 3.32 | 0.51 | 1460 | 17.0 | | | 7.53 | 0.88 | 3.55 |
| 31 | NV07 | Tv4 | 33.8 | 53.8 | | | 2.74 | 0.36 | | 0.37 | | | | | 2.48 | 0.42 | 379 | 30.0 | | | 3.63 | 1.21 | 9.6 |
| 32 | 90-30 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 33 | O57 | Tv2 | 27.5 | 59.8 | | | 5.72 | 1.58 | | 0.74 | | | | | 2.83 | 0.40 | 778 | 6.5 | | | 5.23 | 0.53 | 1.1 |
| 34 | O58 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 35 | O54 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 36 | O72 | Tvu | 46.3 | 84.8 | | | 6.18 | 0.90 | | 0.67 | | | | | 2.38 | 0.34 | 1160 | 15.5 | | | 4.30 | 1.06 | 3.8 |
| 37 | O53 | Tuml | 42.8 | 82.5 | | | 8.31 | 1.52 | | 0.97 | | | | | 3.00 | 0.44 | 992 | 14.1 | | | 6.44 | 1.08 | 3.13 |
| 38 | O52 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 39 | C-21 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 40 | O48 | Tuml | 43.1 | 85.6 | | | 9.52 | 2.13 | | 1.09 | | | | | 3.47 | 0.51 | 1200 | 9.3 | | | 6.56 | 0.76 | 1.84 |
| 41 | O38 | Tuml | 46.8 | 89.4 | | | 9.36 | 2.05 | | 0.92 | | | | | 3.27 | 0.46 | 1320 | 10.6 | | | 7.20 | 0.79 | 2.03 |
| 42 | O39 | Tuml | 35.0 | 63.7 | | | 7.66 | 1.87 | | 0.92 | | | | | 2.65 | 0.40 | 1030 | 6.8 | | | 4.80 | 0.66 | 1.44 |
| 44 | 90-25 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 47 | 90-78 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 48 | 90-79 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 49 | 90-80 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 50 | O23 | Tv6 | 29.1 | 53.3 | | | 5.40 | 0.60 | | 0.82 | | | | | 3.39 | 0.47 | 89 | 20.3 | | | 5.01 | 1.35 | 5.7 |
| 53 | N45 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 54 | C-19 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 55 | O18 | Tv6 | 52.4 | 101 | | | 9.01 | 3.02 | | 0.93 | | | | | 2.93 | 0.45 | 2190 | 12.5 | | | 7.63 | 0.73 | 3.88 |
| 56 | O15 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 59 | O13 | Tv6 | 56.6 | 120 | | | 11.00 | 2.93 | | 1.10 | | | | | 3.48 | 0.49 | 1690 | 9.5 | | | 8.74 | 0.91 | 2.65 |
| 60 | 90-69 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 62 | 90-73 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 63 | O33 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 64 | O-06 | Tv6 | 40.3 | 88.6 | | | 6.79 | 1.61 | | 0.79 | | | | | 2.79 | 0.43 | 2970 | 13.7 | | | 13.40 | 0.97 | 3.78 |
| 65 | N-07 | Tv6 | 41.8 | 76.6 | | | 7.81 | 2.83 | | 0.83 | | | | | 2.39 | 0.33 | 1660 | 6.2 | | | 6.06 | 0.61 | 1.92 |
| 66 | N-09 | Tv6 | 46.5 | 87.9 | | | 7.40 | 0.86 | | 0.66 | | | | | 2.62 | 0.38 | 586 | 25.2 | | | 17.40 | 1.00 | 6.63 |
| 67 | S-22 | Tv2 | 64.54 | 90.61 | 14.23 | 57.46 | 13.28 | 2.73 | 12.12 | 1.98 | 11.68 | 2.29 | 6.07 | 0.87 | 5.52 | 0.85 | 1099 | 15.59 | 15.14 | 60.71 | 7.35 | 1.26 | 5.06 |
| 67 | S-22 | Tv2 | 29.76 | 49.36 | 5.95 | 21.80 | 4.63 | 0.91 | 4.09 | 0.67 | 4.03 | 0.82 | 2.16 | 0.33 | 2.08 | 0.33 | 643 | 15.08 | 10.40 | 22.36 | 4.95 | 0.96 | 4.00 |
| 68 | 90-54 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 69 | 90-53 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 70 | 90-56 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 72 | S-7 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 74 | 90-52 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 75 | 90-15 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 76 | 90-14 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 77 | 90-93 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 78 | 90-12 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 79 | N68 | Tv4 | 11.5 | 22.3 | | | 3.05 | 1.09 | | 0.41 | | | | | 1.40 | 0.20 | 492 | 2.4 | | | 2.25 | 0.26 | 0.71 |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| | SAMPLE | UNIT | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Ba | Th | Nb | Y | Hf | Ta | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | N66 | Tv4 | 18.9 | 40.1 | | | 3.73 | 1.15 | | 0.39 | | | | | 1.40 | 0.19 | 657 | 5.4 | | | 3.01 | 0.34 | 1.47 |
| 82 | O-04 | Tv3 | 46.2 | 96.0 | | | 10.50 | 1.59 | | 1.31 | | | | | 4.87 | 0.68 | 1160 | 18.8 | | | 7.47 | 1.07 | 5.6 |
| 83 | 90-11 | Tv3 | | | | | | | | | | | | | | | | | | | | | |
| 84 | N53 | Tv4 | 31.6 | 47.4 | | | 5.12 | 1.23 | | 0.62 | | | | | 2.03 | 0.30 | 716 | 7.5 | | | 3.62 | 0.44 | 2.21 |
| 85 | 90-9 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 86 | N65 | Tv4 | 17.7 | 37.7 | | | 3.83 | 1.21 | | 0.36 | | | | | 1.42 | 0.21 | 687 | 5.0 | | | 2.80 | 0.30 | 1.22 |
| 87 | W-60 | Tv4 | 10.9 | 24.9 | | | 2.68 | 1.17 | | 0.45 | | | | | 1.33 | 0.20 | 495 | 2.7 | | | 2.37 | | 0.755 |
| 88 | N70 | Tuml | 22.9 | 48.3 | | | 5.29 | 1.72 | | 0.56 | | | | | 1.72 | 0.23 | 758 | 2.3 | | | 3.29 | 0.42 | 0.745 |
| 89 | 90-97 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 90 | 90-19 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 91 | 90-85 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 92 | 90-18 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 93 | 90-60 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 94 | 90-6 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 95 | S-3 | Tv3 | 41.24 | 80.77 | 9.24 | 36.83 | 8.60 | 1.57 | 7.90 | 1.33 | 8.08 | 1.68 | 4.54 | 0.68 | 4.26 | 0.68 | 1106 | 18.17 | 14.80 | 45.69 | 7.16 | 1.13 | 5.56 |
| 96 | 90-46 | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 97 | 90-63 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 98 | 90-64 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 99 | 90-4 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 100 | 90-99 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 101 | 86-40 | Tv4 | 30.6 | 49.6 | | | 2.46 | 0.21 | | 0.33 | | | | | 2.75 | 0.45 | 192 | 34.4 | | | 3.72 | 1.55 | 11.8 |
| 102 | N58 | Tv5 | 40 | 80.0 | | | 8.80 | 1.90 | | 1.10 | | | | | 4.60 | 0.68 | 1240 | 16.0 | | | 8.00 | 0.90 | 5 |
| 103 | N62 | Tv5 | 42 | 82.0 | | | 8.20 | 1.70 | | 1.20 | | | | | 5.20 | 0.78 | 1380 | 20.0 | | | 9.70 | 1.10 | 6.8 |
| 105 | 90-101 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 106 | 90-21 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 107 | 90-100 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 108 | 90-20 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 110 | 90-2 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 111 | 90-106 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 113 | S-6 | Tv3 | 40.22 | 73.35 | 8.45 | 32.88 | 7.38 | 1.20 | 6.87 | 1.15 | 7.05 | 1.47 | 4.14 | 0.62 | 4.01 | 0.65 | 1090 | 17.73 | 15.97 | 42.90 | 7.13 | 1.38 | 5.38 |
| 114 | N55 | Tv5 | 105.0 | 82.5 | | | 19.10 | 3.34 | | 2.13 | | | | | 6.41 | 0.94 | 1010 | 16.0 | | | 7.23 | 0.98 | 5.99 |
| 115 | N57 | Tv5 | 41.2 | 81.3 | | | 8.38 | 1.60 | | 1.15 | | | | | 4.63 | 0.69 | 1250 | 17.5 | | | 8.93 | 0.96 | 5.8 |
| 116 | 90-110 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 118 | N60 | Tv5 | 45.0 | 85.4 | | | 9.69 | 1.68 | | 1.26 | | | | | 5.55 | 0.84 | 1160 | 19.2 | | | 8.80 | 1.10 | 6.5 |
| 120 | S-32 | Tv6 | 38.1 | 75.6 | | | 6.31 | 0.64 | | 0.76 | | | | | 3.53 | 0.52 | 684 | 32.4 | | | 5.59 | 1.40 | 12.5 |
| 121 | N71 | Tuml | 16.7 | 35.6 | | | 3.97 | 1.40 | | 0.48 | | | | | 1.45 | 0.23 | 590 | 2.8 | | | 2.60 | 0.29 | 0.942 |
| 122 | S-23 | Tv6 | 39.17 | 72.64 | 7.93 | 28.83 | 6.05 | 0.85 | 5.13 | 0.87 | 5.29 | 1.11 | 3.13 | 0.49 | 3.21 | 0.51 | 919 | 28.25 | 13.16 | 31.90 | 5.17 | 1.28 | 10.48 |
| 123 | 90-112 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 124 | 90-115 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 126 | 90-117 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 128 | C-13 | Tuml? | | | | | | | | | | | | | | | | | | | | | |
| 129 | C-17B | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 130 | C-14B | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 135 | D77A | KTi | | | | | | | | | | | | | | | | | | | | | |
| 136 | D86A | KTi | | | | | | | | | | | | | | | | | | | | | |
| 140 | D69C | Tv5 | 42.98 | 75.93 | 9.52 | 38.63 | 9.15 | 1.85 | 8.58 | 1.45 | 8.93 | 1.83 | 5.10 | 0.78 | 4.92 | 0.80 | 1414 | 17.45 | 14.61 | 53.17 | 8.83 | 1.79 | 5.95 |
| 142 | D70B | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 145 | D84A | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 146 | D70D | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 149 | D76B | Tfr | 35.69 | 46.29 | 6.68 | 25.51 | 6.70 | 0.10 | 7.66 | 1.64 | 12.00 | 2.73 | 8.26 | 1.30 | 8.17 | 1.23 | 16 | 32.90 | 42.09 | 88.05 | 14.22 | 4.71 | 9.43 |
| 150 | D76A | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 152 | D75A | Tv4 | 38.31 | 72.61 | 8.18 | 31.37 | 6.98 | 1.33 | 6.07 | 1.01 | 6.24 | 1.27 | 3.59 | 0.55 | 3.56 | 0.57 | 1158 | 16.46 | 13.97 | 36.53 | 8.92 | 1.52 | 5.19 |
| 154 | D85B | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 155 | J-140 | Tfr | | | | | | | | | | | | | | | | | | | | | |
| 155 | J-140 | Tfr | 64.97 | 119.51 | 14.59 | 55.60 | 13.47 | 0.18 | 12.54 | 2.28 | 14.73 | 3.07 | 8.64 | 1.32 | 8.39 | 1.28 | 40 | 36.38 | 47.37 | 82.24 | 15.42 | 4.61 | 10.31 |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| | SAMPLE | UNIT | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Ba | Th | Nb | Y | Hf | Ta | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | D53D | Tuml | 17.92 | 35.80 | 4.43 | 19.49 | 4.87 | 1.51 | 4.72 | 0.78 | 4.84 | 1.00 | 2.76 | 0.41 | 2.60 | 0.42 | 747 | 3.10 | 5.00 | 27.11 | 3.42 | 0.84 | 0.80 |
| 159 | J-256 | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | 32.92 | 55.30 | 5.56 | 19.16 | 3.74 | 0.56 | 3.17 | 0.55 | 3.39 | 0.72 | 2.10 | 0.34 | 2.30 | 0.39 | 1036 | 20.83 | 11.80 | 21.89 | 5.03 | 1.66 | 6.92 |
| 163 | J-375 | Tv3 | | | | | | | | | | | | | | | | | | | | | |
| 163 | J-375 | Tv3 | 40.70 | 80.04 | 9.10 | 35.50 | 8.51 | 1.05 | 7.71 | 1.31 | 7.97 | 1.62 | 4.40 | 0.66 | 4.17 | 0.65 | 217 | 20.93 | 22.28 | 45.20 | 6.93 | 2.48 | 7.99 |
| 168 | J-399 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | | | | | | | | | | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | 34.25 | 63.76 | 7.40 | 26.71 | 6.20 | 0.47 | 5.48 | 1.01 | 6.49 | 1.39 | 4.13 | 0.66 | 4.44 | 0.72 | 39 | 21.06 | 21.81 | 40.65 | 7.52 | 2.63 | 6.03 |
| 172 | W-176 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 172 | W-176 | Tuml | 13.94 | 27.31 | 3.45 | 14.94 | 3.86 | 1.08 | 3.78 | 0.62 | 3.81 | 0.79 | 2.18 | 0.31 | 1.97 | 0.32 | 418 | 3.41 | 3.70 | 21.12 | 2.98 | 0.58 | 1.10 |
| 173 | I-151 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 174 | I-112 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | 47.13 | 83.31 | 10.37 | 40.19 | 8.92 | 1.02 | 7.42 | 1.24 | 7.31 | 1.47 | 3.98 | 0.60 | 3.85 | 0.60 | 654 | 21.79 | 18.07 | 38.54 | 8.46 | 2.56 | 6.37 |
| 176 | I-532 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 176 | I-532 | Tuml | 27.52 | 50.05 | 5.91 | 24.02 | 5.25 | 1.47 | 4.57 | 0.70 | 4.09 | 0.79 | 2.13 | 0.32 | 1.98 | 0.32 | 977 | 7.60 | 8.85 | 22.10 | 4.38 | 0.85 | 2.74 |
| 177 | I-44 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 177 | I-44 | Tv4 | 47.79 | 89.03 | 10.11 | 39.55 | 8.87 | 1.01 | 8.03 | 1.37 | 8.37 | 1.74 | 4.87 | 0.73 | 4.73 | 0.75 | 651 | 21.83 | 18.08 | 47.93 | 8.49 | 1.80 | 7.32 |
| 178 | DZ-29 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 179 | DZ-2 | Tv6 | 52.23 | 95.58 | 13.03 | 53.35 | 12.37 | 2.95 | 10.23 | 1.65 | 9.73 | 1.92 | 5.23 | 0.79 | 5.00 | 0.79 | 1741 | 11.91 | 21.15 | 50.41 | 10.08 | 2.04 | 3.93 |
| 181 | I-133 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 181 | I-133 | Tuml | 26.60 | 52.28 | 6.49 | 27.77 | 6.35 | 1.95 | 5.88 | 0.88 | 5.06 | 1.00 | 2.60 | 0.36 | 2.16 | 0.33 | 722 | 3.94 | 8.25 | 26.67 | 4.14 | 0.90 | 1.11 |
| 184 | I-478 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 186 | HF-1 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 187 | VG-7B | Tv4 | 32.52 | 63.91 | 7.27 | 28.10 | 6.93 | 0.76 | 6.33 | 1.16 | 7.21 | 1.51 | 4.26 | 0.65 | 4.20 | 0.67 | 236 | 18.47 | 15.82 | 43.41 | 6.70 | 2.19 | 4.74 |
| 190 | PLM | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 190 | PLM | Tuml | 44.64 | 84.82 | 10.43 | 43.93 | 10.07 | 2.68 | 9.20 | 1.43 | 8.39 | 1.69 | 4.47 | 0.64 | 4.00 | 0.63 | 1242 | 9.02 | 18.39 | 45.10 | 8.76 | 1.45 | 3.06 |
| 191 | HW-1 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | 40.86 | 74.54 | 9.34 | 38.52 | 8.93 | 2.10 | 8.22 | 1.38 | 8.31 | 1.72 | 4.76 | 0.72 | 4.53 | 0.73 | 1109 | 9.48 | 16.84 | 48.08 | 10.40 | 1.72 | 3.26 |
| 193 | J-CH | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | 43.13 | 77.24 | 10.18 | 43.39 | 10.16 | 2.96 | 9.45 | 1.48 | 8.86 | 1.81 | 4.91 | 0.72 | 4.56 | 0.73 | 1479 | 7.66 | 14.15 | 50.60 | 8.76 | 1.13 | 3.44 |
| 195 | Ni-30 | Tv6 | | | | | | | | | | | | | | | | | | | | | |
| 199 | ER-51 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 201 | CG-BL | Tv2 | | | | | | | | | | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | 33.00 | 69.87 | 8.43 | 33.73 | 8.56 | 0.43 | 7.78 | 1.33 | 8.05 | 1.59 | 4.29 | 0.62 | 3.86 | 0.61 | 45 | 15.90 | 17.42 | 42.71 | 7.06 | 2.72 | 5.26 |
| 203 | Monz | KTi | | | | | | | | | | | | | | | | | | | | | |
| 205 | Z-VIT | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 207 | RED | Tv1 | 45.69 | 79.30 | 8.35 | 29.50 | 5.79 | 1.04 | 4.50 | 0.72 | 4.03 | 0.80 | 2.18 | 0.33 | 2.12 | 0.34 | 810 | 37.52 | 18.17 | 23.12 | 6.30 | 2.29 | 11.19 |
| 208 | RP | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 211 | EC1 | Tv4 | 28.72 | 53.64 | 6.51 | 27.76 | 8.16 | 0.35 | 8.70 | 1.72 | 11.46 | 2.44 | 7.10 | 1.10 | 6.98 | 1.10 | 43 | 29.51 | 33.50 | 75.18 | 11.14 | 3.51 | 6.49 |
| 212 | ECD | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 213 | 4RSRB | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 214 | RND1 | Tv4 | 64.63 | 123.14 | 13.96 | 54.51 | 11.72 | 1.45 | 10.15 | 1.66 | 10.19 | 2.06 | 5.64 | 0.84 | 5.28 | 0.83 | 722 | 13.90 | 22.29 | 55.95 | 9.87 | 2.19 | 3.10 |
| 215 | TTV | Tv4 | 52.86 | 99.31 | 10.96 | 42.00 | 9.17 | 1.58 | 8.03 | 1.35 | 8.43 | 1.73 | 4.81 | 0.74 | 4.70 | 0.75 | 1253 | 14.77 | 24.34 | 47.98 | 9.62 | 2.56 | 3.95 |
| 217 | 4EN1 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 218 | 4MPB | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 219 | PMES1 | Tv4 | | | | | | | | | | | | | | | | | | | | | |
| 220 | CLLD | Tv4 | 52.32 | 93.56 | 9.93 | 35.01 | 7.19 | 0.49 | 5.96 | 1.05 | 6.61 | 1.38 | 3.96 | 0.63 | 4.14 | 0.65 | 260 | 21.90 | 24.07 | 39.20 | 5.40 | 2.49 | 4.61 |
| 221 | OWLD | Tv4 | 49.54 | 87.23 | 9.56 | 36.89 | 7.87 | 2.04 | 7.20 | 1.17 | 7.29 | 1.51 | 4.19 | 0.63 | 3.97 | 0.65 | 2256 | 12.59 | 19.83 | 44.25 | 11.13 | 2.51 | 3.20 |
| 222 | 4BAS1 | Tuml | | | | | | | | | | | | | | | | | | | | | |
| 223 | XYZB | Tuml | | | | | | | | | | | | | | | | | | | | | |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| # | Sample | UNIT | Pb | Rb | Cs | Sr | Sc | Zr | W | Co | V | As | Sb | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Tuml | 8.24 | 41.3 | 1.07 | 677 | 20.7 | 236 | 30.4 | | | | | |
| 2 | 3-21-2 | Tv7 | 25.78 | 208.2 | 5.56 | 152 | 3.2 | 206 | 47.7 | | | | | |
| 3 | 3-20-3 | Tuml | | | | | | | | | | | | |
| 6 | 3-20-1 | Tuml | 7.77 | 33.6 | 1.10 | 790 | 29.5 | 164 | 22.5 | | | | | |
| 8 | Ma-1 | KTi | | | | | | | | | | | | |
| 10 | 12-11-3 | Tvu | | | | | | | | | | | | |
| 13 | 11-14-1 | Tvu | | | | | | | | | | | | |
| 15 | 10-23-5 | Tvu | 15.98 | 100.0 | 2.53 | 146 | 1.4 | 72 | 94.1 | | | | | |
| 19 | BV5 | Tvu | 15.79 | 108.7 | 3.32 | 176 | 2.0 | 76 | 74.3 | | | | | |
| 21 | 3-23-1 | Tuml | 13.13 | 125.8 | 2.48 | 468 | 12.6 | 246 | 42.6 | | | | | |
| 22 | 10-25-2 | Tv4 | | | | | | | | | | | | |
| 25 | 90-29 | Tv2 | | | | | | | | | | | | |
| 28 | NV11 | Tv4 | | | 2.5 | | 4.9 | | | 3.8 | 37 | 6.7 | 1.1 | |
| 29 | NV01 | Tv4 | | | 5.8 | | 5.6 | | | 1.3 | 13 | 13.2 | 2.1 | 143 |
| 31 | NV07 | Tv4 | | | 9.7 | | 3.2 | | | 1.2 | 11 | 7.8 | 2.2 | 430 |
| 32 | 90-30 | Tv2 | | | | | | | | | | | | |
| 33 | O57 | Tv2 | | | 5.5 | | 15.4 | | | 15.1 | 125 | | | |
| 34 | O58 | Tv2 | | | | | | | | | | | | |
| 35 | O54 | Tuml | | | | | | | | | | | | |
| 36 | O72 | Tvu | | | 3.5 | | 2.8 | | | 0.3 | | 2.5 | 0.4 | 600 |
| 37 | O53 | Tuml | | | 3.3 | | 9.7 | | | 9.5 | 84 | 2.8 | 0.4 | 351 |
| 38 | O52 | Tuml | | | | | | | | | | | | |
| 39 | C-21 | Tv4 | | | | | | | | | | | | |
| 40 | O48 | Tuml | | | 5.5 | | 9.4 | | | 6.6 | 48 | 1.4 | 0.2 | 345 |
| 41 | O38 | Tuml | | | 1.5 | | 5.6 | | | 1.8 | 14 | | | |
| 42 | O39 | Tuml | | | 1.5 | | 15.0 | | | 11.3 | 110 | | | 285 |
| 44 | 90-25 | Tv2 | | | | | | | | | | | | |
| 47 | 90-78 | Tv2 | | | | | | | | | | | | |
| 48 | 90-79 | Tv2 | | | | | | | | | | | | |
| 49 | 90-80 | Tv2 | | | | | | | | | | | | |
| 50 | O23 | Tv6 | | | 3.3 | | 4.0 | | | 0.3 | | 9.5 | 1.8 | |
| 53 | N45 | Tv2 | | | | | | | | | | | | |
| 54 | C-19 | Tv4 | | | | | | | | | | | | |
| 55 | O18 | Tv6 | | | 3.0 | | 12.5 | | | 10.1 | 93 | | 0.3 | 169 |
| 56 | O15 | Tv6 | | | | | | | | | | | | |
| 59 | O13 | Tv6 | | | 1.9 | | 16.1 | | | 19.0 | 150 | | 0.3 | 312 |
| 60 | 90-69 | Tv2 | | | | | | | | | | | | |
| 62 | 90-73 | Tv2 | | | | | | | | | | | | |
| 63 | O33 | Tv4 | | | | | | | | | | | | |
| 64 | O-06 | Tv6 | | | 1.8 | | 6.7 | | | 5.2 | 40 | | | |
| 65 | N-07 | Tv6 | | | 2.6 | | 18.5 | | | 20.3 | 162 | 4.1 | | |
| 66 | N-09 | Tv6 | | | 5.3 | | 3.4 | | | 4.5 | 16 | 7.1 | | |
| 67 | S-22 | Tv2 | 18.22 | 175.5 | 6.25 | 284 | 11.4 | 250 | 1.5 | | | | | |
| 67 | S-22 | Tv2 | 15.47 | 170.4 | 6.22 | 124 | 6.8 | 158 | 3.3 | | | | | |
| 68 | 90-54 | Tv2 | | | | | | | | | | | | |
| 69 | 90-53 | Tv2 | | | | | | | | | | | | |
| 70 | 90-56 | Tv2 | | | | | | | | | | | | |
| 72 | S-7 | Tv6 | | | | | | | | | | | | |
| 74 | 90-52 | Tv2 | | | | | | | | | | | | |
| 75 | 90-15 | Tv4 | | | | | | | | | | | | |
| 76 | 90-14 | Tv4 | | | | | | | | | | | | |
| 77 | 90-93 | Tv4 | | | | | | | | | | | | |
| 78 | 90-12 | Tv4 | | | | | | | | | | | | |
| 79 | N68 | Tv4 | | | 14.0 | | 19.6 | | | 25.8 | 196 | | | |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| # | Sample | UNIT | Pb | Rb | Cs | Sr | Sc | Zr | W | Co | V | As | Sb | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | N66 | Tv4 | | | 2.0 | | 16.0 | | | 21.6 | 143 | | 0.2 | |
| 82 | O-04 | Tv3 | | | 13.8 | | 4.6 | | | 0.5 | | 12.0 | 3.0 | 741 |
| 83 | 90-11 | Tv3 | | | | | | | | | | | | |
| 84 | N53 | Tv4 | | | 9.8 | | 14.6 | | | 19.6 | 122 | 3.0 | 0.4 | |
| 85 | 90-9 | Tv4 | | | | | | | | | | | | |
| 86 | N65 | Tv4 | | | 1.2 | | 16.2 | | | 22.2 | 158 | | 0.2 | |
| 87 | W-60 | Tv4 | | | 14.9 | | 20.0 | | | 26.1 | 170 | | | |
| 88 | N70 | Tuml | | | 0.4 | | 12.1 | | | 31.8 | 140 | | | |
| 89 | 90-97 | Tuml | | | | | | | | | | | | |
| 90 | 90-19 | Tv4 | | | | | | | | | | | | |
| 91 | 90-85 | Tv4 | | | | | | | | | | | | |
| 92 | 90-18 | Tv4 | | | | | | | | | | | | |
| 93 | 90-60 | Tuml | | | | | | | | | | | | |
| 94 | 90-6 | Tv4 | | | | | | | | | | | | |
| 95 | S-3 | Tv3 | 22.50 | 243.3 | 14.21 | 118 | 5.2 | 234 | 2.7 | | | | | |
| 96 | 90-46 | Tv2 | | | | | | | | | | | | |
| 97 | 90-63 | Tuml | | | | | | | | | | | | |
| 98 | 90-64 | Tuml | | | | | | | | | | | | |
| 99 | 90-4 | Tv4 | | | | | | | | | | | | |
| 100 | 90-99 | Tuml | | | | | | | | | | | | |
| 101 | 86-40 | Tv4 | | | 11.8 | | 2.4 | | | 1.0 | | 14.3 | 3.0 | 506 |
| 102 | N58 | Tv5 | | | 2.3 | | 7.6 | | | 1.9 | 23 | 7.6 | 2.0 | |
| 103 | N62 | Tv5 | | | 4.8 | | 5.8 | | | 0.7 | 7 | 5.7 | 1.4 | 165 |
| 105 | 90-101 | Tuml | | | | | | | | | | | | |
| 106 | 90-21 | Tuml | | | | | | | | | | | | |
| 107 | 90-100 | Tuml | | | | | | | | | | | | |
| 108 | 90-20 | Tuml | | | | | | | | | | | | |
| 110 | 90-2 | Tv4 | | | | | | | | | | | | |
| 111 | 90-106 | Tv4 | | | | | | | | | | | | |
| 113 | S-6 | Tv3 | 21.61 | 168.1 | 5.72 | 239 | 9.1 | 238 | 2.3 | | | | | |
| 114 | N55 | Tv5 | | | 2.1 | | 8.9 | | | 5.2 | 50 | 5.4 | 0.8 | |
| 115 | N57 | Tv5 | | | 42.4 | | 6.5 | | | 1.0 | 12 | 10.5 | 2.1 | 576 |
| 116 | 90-110 | Tuml | | | | | | | | | | | | |
| 118 | N60 | Tv5 | | | 13.5 | | 5.5 | | | 0.9 | | 7.7 | 1.6 | 816 |
| 120 | S-32 | Tv6 | | | 12.4 | | 2.8 | | | 1.1 | 9 | 9.6 | 2.2 | 597 |
| 121 | N71 | Tuml | | | 1.1 | | 14.0 | | | 23.4 | 159 | | | 484 |
| 122 | S-23 | Tv6 | 23.45 | 216.8 | 13.03 | 117 | 4.4 | 149 | 3.4 | | | | | |
| 123 | 90-112 | Tuml | | | | | | | | | | | | |
| 124 | 90-115 | Tuml | | | | | | | | | | | | |
| 126 | 90-117 | Tuml | | | | | | | | | | | | |
| 128 | C-13 | Tuml? | | | | | | | | | | | | |
| 129 | C-17B | Tv5 | | | | | | | | | | | | |
| 130 | C-14B | Tv4 | | | | | | | | | | | | |
| 135 | D77A | KTi | | | | | | | | | | | | |
| 136 | D86A | KTi | | | | | | | | | | | | |
| 140 | D69C | Tv5 | 33.02 | 185.7 | 11.14 | 121 | 7.4 | 311 | 75.5 | | | | | |
| 142 | D70B | Tv4 | | | | | | | | | | | | |
| 145 | D84A | Tv5 | | | | | | | | | | | | |
| 146 | D70D | Tuml | | | | | | | | | | | | |
| 149 | D76B | Tfr | 38.50 | 310.5 | 10.52 | 6 | 0.6 | 396 | 177.4 | | | | | |
| 150 | D76A | Tuml | | | | | | | | | | | | |
| 152 | D75A | Tv4 | 24.04 | 178.1 | 6.84 | 239 | 5.4 | 319 | 59.5 | | | | | |
| 154 | D85B | Tv5 | | | | | | | | | | | | |
| 155 | J-140 | Tfr | | | | | | | | | | | | |
| 155 | J-140 | Tfr | 40.30 | 318.0 | 6.59 | 9 | 0.9 | 441 | 125.0 | | | | | |

(*continued*)

TABLE 4. TRACE ELEMENT DATA (*continued*)

| # | Sample | UNIT | Pb | Rb | Cs | Sr | Sc | Zr | W | Co | V | As | Sb | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | D53D | Tuml | 9.14 | 24.3 | 0.74 | 684 | 27.1 | 124 | 65.1 | | | | | |
| 159 | J-256 | Tv5 | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | | | | | | | | | | | | |
| 160 | J-369 | Tv5 | 18.27 | 224.8 | 7.84 | 128 | 2.6 | 168 | 69.6 | | | | | |
| 163 | J-375 | Tv3 | | | | | | | | | | | | |
| 163 | J-375 | Tv3 | 26.93 | 203.0 | 46.27 | 128 | 5.3 | 198 | 114.0 | | | | | |
| 168 | J-399 | Tv6 | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | | | | | | | | | | | | |
| 170 | W-200 | Tv5 | 17.42 | 203.8 | 4.04 | 5 | 2.8 | 201 | 148.1 | | | | | |
| 172 | W-176 | Tuml | | | | | | | | | | | | |
| 172 | W-176 | Tuml | 6.01 | 32.7 | 0.74 | 485 | 34.8 | 102 | 47.3 | | | | | |
| 173 | I-151 | Tv4 | | | | | | | | | | | | |
| 174 | I-112 | Tv4 | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | | | | | | | | | | | | |
| 175 | I-521 | Tv4 | 20.10 | 183.8 | 5.30 | 12 | 7.6 | 279 | 144.2 | | | | | |
| 176 | I-532 | Tuml | | | | | | | | | | | | |
| 176 | I-532 | Tuml | 11.56 | 70.7 | 2.48 | 586 | 12.8 | 163 | 30.5 | | | | | |
| 177 | I-44 | Tv4 | | | | | | | | | | | | |
| 177 | I-44 | Tv4 | 20.81 | 194.1 | 7.46 | 9 | 7.5 | 280 | 40.2 | | | | | |
| 178 | DZ-29 | Tv6 | | | | | | | | | | | | |
| 179 | DZ-2 | Tv6 | 18.81 | 115.1 | 3.85 | 130 | 5.7 | 356 | 102.8 | | | | | |
| 181 | I-133 | Tuml | | | | | | | | | | | | |
| 181 | I-133 | Tuml | 8.40 | 31.9 | 0.74 | 857 | 23.6 | 163 | 57.1 | | | | | |
| 184 | I-478 | Tv4 | | | | | | | | | | | | |
| 186 | HF-1 | Tuml | | | | | | | | | | | | |
| 187 | VG-7B | Tv4 | 19.35 | 186.4 | 5.20 | 13 | 3.2 | 203 | 140.7 | | | | | |
| 190 | PLM | Tuml | | | | | | | | | | | | |
| 190 | PLM | Tuml | 15.47 | 65.3 | 2.69 | 503 | 17.0 | 351 | 46.1 | | | | | |
| 191 | HW-1 | Tuml | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | | | | | | | | | | | | |
| 192 | Ni-102 | Tv6 | 15.29 | 111.0 | 3.61 | 176 | 7.4 | 404 | 76.8 | | | | | |
| 193 | J-CH | Tv4 | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | | | | | | | | | | | | |
| 194 | PC-1 | Tuml | 16.57 | 88.3 | 2.21 | 606 | 6.5 | 454 | 38.7 | | | | | |
| 195 | Ni-30 | Tv6 | | | | | | | | | | | | |
| 199 | ER-51 | Tv4 | | | | | | | | | | | | |
| 201 | CG-BL | Tv2 | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | | | | | | | | | | | | |
| 202 | NJ-5 | Tv4 | 24.44 | 206.8 | 19.05 | 124 | 4.4 | 239 | 182.7 | | | | | |
| 203 | Monz | KTi | | | | | | | | | | | | |
| 205 | Z-VIT | Tv4 | | | | | | | | | | | | |
| 207 | RED | Tv1 | 25.24 | 267.4 | 13.82 | 212 | 4.7 | 220 | 60.0 | | | | | |
| 208 | RP | Tv4 | | | | | | | | | | | | |
| 211 | EC1 | Tv4 | 34.23 | 315.3 | 8.11 | 14 | 3.5 | 281 | 108.9 | | | | | |
| 212 | ECD | Tuml | | | | | | | | | | | | |
| 213 | 4RSRB | Tuml | | | | | | | | | | | | |
| 214 | RND1 | Tv4 | 28.48 | 144.3 | 2.31 | 49 | 6.7 | 344 | 101.7 | | | | | |
| 215 | TTV | Tv4 | 27.27 | 188.2 | 44.27 | 206 | 4.8 | 352 | 114.9 | | | | | |
| 217 | 4EN1 | Tv4 | | | | | | | | | | | | |
| 218 | 4MPB | Tuml | | | | | | | | | | | | |
| 219 | PMES1 | Tv4 | | | | | | | | | | | | |
| 220 | CLLD | Tv4 | 28.02 | 201.4 | 4.98 | 37 | 3.0 | 150 | 59.3 | | | | | |
| 221 | OWLD | Tv4 | 19.99 | 131.4 | 2.71 | 157 | 6.9 | 461 | 153.7 | | | | | |
| 222 | 4BAS1 | Tuml | | | | | | | | | | | | |
| 223 | XYZB | Tuml | | | | | | | | | | | | |

*Note:* Techniques (Tech.):T1—analyses at University of Texas, Austin, by XRF (Rb, Sr, Y, Zr, Nb only). T2—analyses at Washington State University Geoanalytical Lab by X-ray Fluorescence and/or ICP-MS. T3—analyses at University of Massachusetts, Amherst, by X-ray Fluorescence. T4—analyses at Oregon State University by Neutron Activation. T5—analyses at Los Alamos National Laboratory by Neutron Activation. All values are in ppm. Reference (Ref.):1—Wark (1991).

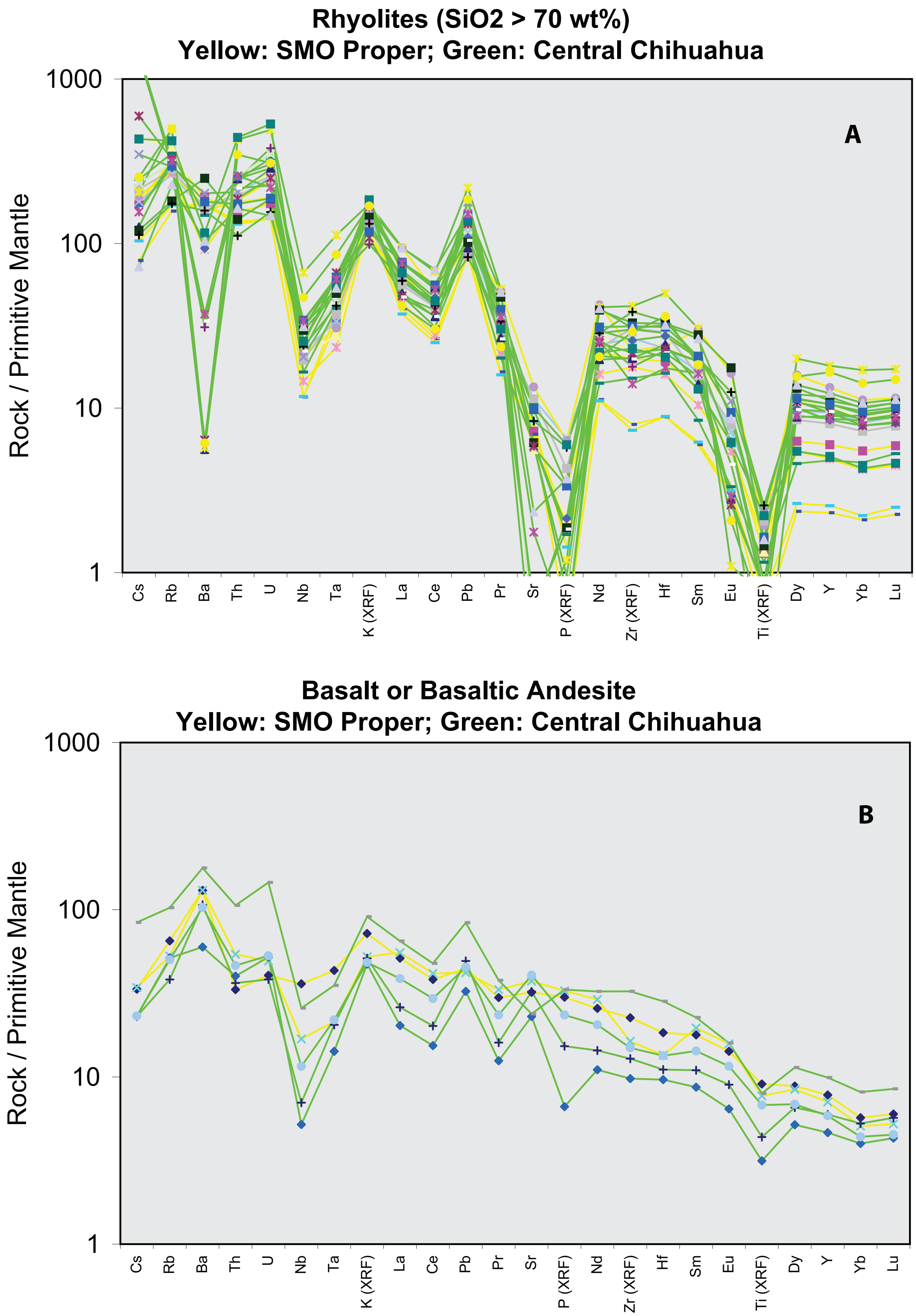



Figure 4. (A) Element variation diagrams are plotted for individual analyses of rhyolites from the Sierra Madre Occidental proper (yellow lines) and central Chihuahua (green lines). (B) Equivalent plot for analyzed rocks of basalt or basaltic andesite composition. All analyses in A and B have been normalized to the values in Sun and McDonough (1989).

TABLE 5. K-Ar AGES

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×10$^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Tuml | whole rock | 1.669 | 40 | 1.174 | 18.4 | ± | 0.4 | |
| | | | | 1.680 | 52 | 1.226 | | | | |
| 2 | 3-21-2 | Tv7 | biotite | 6.882 | 66 | 6.345 | 24.0 | ± | 0.4 | |
| | | | | 6.776 | 69 | 6.49 | | | | |
| 2 | 3-21-2 | Tv7 | plagioclase | 0.635 | 55 | 0.5646 | 22.4 | ± | 0.5 | |
| | | | | 0.636 | 54 | 0.5479 | | | | |
| 4 | 3-20-4 | Tv7 | plagioclase | 0.628 | 52 | 0.5962 | 23.3 | ± | 1.1 | |
| | | | | 0.695 | 56 | 0.6129 | | | | |
| | | | | 0.670 | | | | | | |
| | | | | 0.663 | | | | | | |
| 5 | 12-13-3 | Tuml | plagioclase | 0.441 | 36 | 0.4219 | 25.5 | ± | 1.4 | |
| | | | | 0.439 | 33 | 0.455 | | | | |
| 7 | 11-16-2 | Tuml | whole rock | 1.318 | 61 | 1.225 | 24.1 | ± | 0.5 | |
| | | | | 1.303 | 72 | 1.249 | | | | |
| 8 | Ma-1 | KTi | biotite | 7.218 | 82 | 17.56 | 62.8 | ± | 1.0 | |
| | | | | 7.111 | 90 | 17.99 | | | | |
| 11 | 11-15-1 | Tv4 | biotite | 7.198 | 82 | 9.513 | 34.1 | ± | 0.5 | |
| | | | | 7.143 | 80 | 9.652 | | | | |
| 11 | 11-15-1 | Tv4 | k-felds | 9.033 | 96 | 11.92 | 33.3 | ± | 0.7 | |
| | | | | 9.088 | 96 | 11.75 | | | | |
| 12 | 11-16-4 | Tv4 | biotite | 6.941 | 61 | 8.937 | 33.0 | ± | 0.5 | |
| | | | | 6.980 | 65 | 9.082 | | | | |
| 12 | 11-16-4 | Tv4 | k-felds | 9.278 | 94 | 11.87 | 32.3 | ± | 0.7 | |
| | | | | 9.191 | 95 | 11.51 | | | | |
| 13 | 11-14-1 | Tvu | plagioclase | 0.315 | 29 | 0.4138 | 32.0 | ± | 1.9 | |
| | | | | 0.318 | 30 | 0.3808 | | | | |
| 14 | C-2 | Tvu | whole rock | 1.166 | 63 | 1.36 | 29.5 | ± | 0.6 | |
| | | | | 1.161 | 65 | 1.33 | | | | |
| 14 | C-2 | Tvu | plagioclase | 0.146 | 19 | 0.213 | 33.2 | ± | 3.6 | |
| | | | | 0.152 | 13 | 0.186 | | | | |
| | | | | 0.161 | | | | | | |
| 16 | C-1 | Tv6 | plagioclase | 0.554 | 48 | 0.642 | 29.3 | ± | 0.7 | |
| | | | | 0.551 | 45 | 0.627 | | | | |
| 16 | C-1 | Tv6 | biotite | 6.46 | 77 | 7.67 | 30.2 | ± | 0.5 | |
| | | | | 6.46 | 75 | 7.62 | | | | |
| 17 | 3-25-4 | Tv6 | biotite | 6.611 | 49 | 7.451 | 29.0 | ± | 0.5 | 1 |
| | | | | 6.636 | 60 | 7.582 | | | | |
| 18 | 10-20-1 | Tv4 | biotite | 6.852 | 61 | 9.088 | 33.9 | ± | 0.5 | |
| | | | | 6.873 | 70 | 9.173 | | | | |
| 18 | 10-20-1 | Tv4 | plagioclase | 0.641 | 40 | 0.7516 | 29.0 | ± | 1.4 | |
| | | | | 0.639 | 45 | 0.7045 | | | | |
| 19 | BV5 | Tvu | biotite | 7.183 | 73 | 8.529 | 30.3 | ± | 0.5 | |
| | | | | 7.250 | 81 | 8.596 | | | | |
| 20 | 3-25-3 | Tvu | plagioclase | 0.392 | 40 | 0.5073 | 31.8 | ± | 2.0 | |
| | | | | 0.390 | 48 | 0.4652 | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×10$^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 3-23-1 | Tuml | plagioclase | 0.376 | 19 | 0.3853 | 26.3 | ± | 0.9 | |
| | | | | 0.371 | 27 | 0.3841 | | | | |
| 23 | O59 | Tv6 | plagioclase | 0.603 | 52 | 0.653 | 28.0 | ± | 0.7 | 1 |
| | | | | 0.590 | | | | | | |
| 24 | C-4 | Tv6 | plagioclase | 0.344 | 17 | 0.424 | 30.2 | ± | 1.7 | |
| | | | | 0.368 | 16 | 0.418 | | | | |
| 24 | C-4 | Tv6 | biotite | 6.59 | 70 | 8.08 | 31.4 | ± | 0.5 | |
| | | | | 6.68 | 75 | 8.26 | | | | |
| 26 | C-6 | Tv6 | plagioclase | 0.301 | 19 | 0.368 | 30.8 | ± | 0.9 | |
| | | | | 0.301 | 21 | 0.358 | | | | |
| 26 | C-6 | Tv6 | amphibole | 0.481 | 31 | 0.540 | 28.8 | ± | 0.6 | |
| | | | | 0.478 | 56 | 0.541 | | | | |
| 26 | C-6 | Tv6 | biotite | 6.13 | 71 | 7.71 | 31.8 | ± | 0.5 | |
| | | | | 6.25 | 68 | 7.59 | | | | |
| | | | | | 81 | 7.84 | | | | |
| 27 | J22B | Tv2 | plagioclase | 0.169 | 16 | 0.215 | 37.6 | ± | 6.8 | 1 |
| | | | | 0.165 | 22 | 0.277 | | | | |
| 30 | J22A | Tv2 | plagioclase | 0.159 | 8 | 0.200 | 32.2 | ± | 1.8 | 1 |
| 39 | C-21 | Tv4 | plagioclase | 0.375 | 52 | 0.519 | 34.7 | ± | 0.8 | 1,3 |
| | | | | 0.379 | 46 | 0.507 | | | | |
| 45 | J18 | Tv2 | plagioclase | 0.259 | 31 | 0.404 | 39.7 | ± | 1.7 | |
| 46 | J23 | Tv6 | plagioclase | 1.317 | 44 | 1.381 | 27.4 | ± | 0.6 | 1 |
| | | | | 1.299 | 60 | 1.422 | | | | |
| 51 | C-20 | Tv6 | plagioclase | 0.628 | 70 | 0.731 | 28.8 | ± | 0.7 | 1,3 |
| | | | | 0.643 | 56 | 0.703 | | | | |
| 52 | P18A | Tv6 | k-felds | 4.29 | 75 | 5.15 | 30.2 | ± | 0.6 | 1,3 |
| | | | | 4.26 | 82 | 4.97 | | | | |
| 54 | C-19 | Tv4 | plagioclase | 0.323 | 30 | 0.481 | 34.4 | ± | 0.8 | 1,3 |
| | | | | 0.318 | 44 | 0.432 | | | | |
| 55 | O18 | Tv6 | k-felds | 3.785 | 81 | 4.374 | 30.5 | ± | 0.7 | 1 |
| | | | | 3.628 | 75 | 4.481 | | | | |
| 57 | S-27 | Tv4 | k-felds | 6.424 | 90 | 9.219 | 35.8 | ± | 0.8 | 1 |
| | | | | 6.494 | 92 | 8.940 | | | | |
| 58 | S-14 | Tv6 | k-felds | 5.283 | 85 | 5.967 | 29.2 | ± | 0.6 | |
| | | | | 5.332 | 86 | 6.193 | | | | |
| 61 | S-17 | Tv3 | biotite | 6.897 | 71 | 9.226 | 33.9 | ± | 0.5 | 1 |
| | | | | 6.967 | | | | | | |
| 61 | S-17 | Tv3 | plagioclase | 0.512 | 44 | 0.747 | 36.8 | ± | 1.3 | 1 |
| | | | | 0.500 | 31 | 0.716 | | | | |
| 66 | N-09 | Tv6 | k-felds | 5.752 | 91 | 6.384 | 28.8 | ± | 0.6 | 1 |
| | | | | 5.566 | | | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×$10^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 67 | S-22 | Tv2 | biotite | 6.605 | 54 | 9.930 | 38.2 | ± | 0.6 | 1 |
| | | | | 6.493 | 58 | 9.708 | | | | |
| | | | | 6.553 | | | | | | |
| 71 | M11 | Tuml | whole rock | 0.267 | 29 | 0.297 | 30.4 | ± | 2.8 | 1 |
| | | | | 0.235 | 28 | 0.300 | | | | |
| 72 | S-7 | Tv6 | k-felds | 4.917 | 59 | 5.696 | 29.3 | ± | 0.6 | 1 |
| | | | | 4.948 | 86 | 5.639 | | | | |
| 72 | S-7 | Tv6 | biotite | 6.712 | 70 | 7.772 | 29.0 | ± | 0.9 | 1 |
| | | | | | 62 | 7.465 | | | | |
| 73 | S-19 | Tv3 | biotite | 6.052 | 70 | 9.155 | 38.5 | ± | 0.6 | 1 |
| | | | | 6.128 | 67 | 9.240 | | | | |
| 73 | S-19 | Tv3 | plagioclase | 0.636 | 49 | 0.867 | 37.3 | ± | 3.6 | 1 |
| | | | | 0.630 | 44 | 0.992 | | | | |
| | | | | 0.637 | | | | | | |
| 80 | S-9 | Tv3 | biotite | 6.976 | 79 | 9.887 | 36.4 | ± | 0.6 | 1 |
| | | | | 6.909 | 88 | 9.950 | | | | |
| 80 | S-9 | Tv3 | plagioclase | 0.750 | 64 | 1.049 | 35.6 | ± | 0.8 | 1 |
| | | | | 0.734 | 52 | 1.024 | | | | |
| 95 | S-3 | Tv3 | biotite | 6.307 | 76 | 8.907 | 36.8 | ± | 0.6 | 1 |
| | | | | 6.119 | 77 | 9.021 | | | | |
| 95 | S-3 | Tv3 | plagioclase | 0.606 | 34 | 0.866 | 35.6 | ± | 1.5 | 1 |
| | | | | 0.624 | 32 | 0.851 | | | | |
| 104 | S-8 | Tv4 | biotite | 6.785 | 68 | 8.740 | 32.4 | ± | 0.5 | 1 |
| | | | | 6.967 | | | | | | |
| 104 | S-8 | Tv4 | k-felds | 5.605 | 75 | 7.656 | 34.4 | ± | 0.7 | 1 |
| | | | | 5.611 | 84 | 7.498 | | | | |
| 109 | S-4 | Tv5 | k-felds | 2.117 | 76 | 2.600 | 31.0 | ± | 0.7 | 1 |
| | | | | 2.112 | 77 | 2.542 | | | | |
| 112 | S-5 | Tv3 | biotite | 7.124 | 81 | 10.019 | 35.8 | ± | 0.6 | 1 |
| | | | | 7.075 | 81 | 9.925 | | | | |
| 112 | S-5 | Tv3 | plagioclase | 0.978 | 62 | 1.226 | 32.5 | ± | 2.0 | 1 |
| | | | | 1.019 | 64 | 1.331 | | | | |
| | | | | 1.011 | | | | | | |
| 113 | S-6 | Tv3 | biotite | 7.062 | 83 | 9.911 | 35.7 | ± | 0.6 | 1 |
| | | | | 7.097 | 87 | 9.925 | | | | |
| 119 | S-31 | Tv5 | k-felds | 2.212 | 83 | 2.760 | 31.7 | ± | 0.7 | 1 |
| | | | | 2.220 | 68 | 2.749 | | | | |
| 120 | S-32 | Tv6 | plagioclase | 0.492 | 43 | 0.591 | 30.6 | ± | 0.7 | |
| | | | | 0.496 | 47 | 0.593 | | | | |
| 120 | S-32 | Tv6 | biotite | 6.859 | 69 | 8.533 | 31.8 | ± | 0.5 | |
| | | | | 6.929 | 65 | 8.678 | | | | |
| 122 | S-23 | Tv6 | plagioclase | 0.499 | 39 | 0.614 | 31.4 | ± | 0.7 | |
| | | | | 0.496 | 41 | 0.609 | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar $\times 10^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 125 | S-28 | Tv5 | plagioclase | 0.748 | 61 | 0.958 | 31.8 | ± | 1.2 | 1 |
| | | | | 0.755 | 49 | 0.913 | | | | |
| 127 | C-18 | Tv6 | plagioclase | 0.600 | 62 | 0.695 | 30.0 | ± | 0.7 | 1,3 |
| | | | | 0.608 | 66 | 0.723 | | | | |
| 131 | C-12 | Tv5 | plagioclase | 0.768 | 69 | 0.985 | 31.7 | ± | 0.7 | 1,3 |
| | | | | 0.770 | 68 | 0.926 | | | | |
| 132 | C-7 | Tv4 | k-felds | 8.69 | 90 | 11.42 | 33.1 | ± | 0.7 | 1,3 |
| | | | | 8.60 | 92 | 11.09 | | | | |
| | | | | 8.81 | | | | | | |
| | | | | 8.63 | | | | | | |
| 132 | C-7 | Tv4 | biotite | 6.93 | 76 | 9.30 | 34.0 | ± | 0.5 | 1,3 |
| | | | | 6.93 | 73 | 9.20 | | | | |
| 133 | S-25 | Tv4 | biotite | 7.270 | 80 | 9.702 | 34.1 | ± | 0.5 | 1 |
| | | | | 7.397 | 90 | 9.886 | | | | |
| 133 | S-25 | Tv4 | plagioclase | 0.447 | 48 | 0.568 | 33.3 | ± | 1.5 | 1 |
| | | | | 0.452 | 49 | 0.605 | | | | |
| 134 | S-24 | Tv4 | k-felds | 3.969 | 82 | 5.282 | 33.3 | ± | 0.7 | 1 |
| | | | | 3.962 | 78 | 5.065 | | | | |
| 137 | D66B | Tv4 | plagioclase | 0.5051 | 40 | 0.5438 | 29.8 | ± | 3.4 | |
| | | | | 0.5090 | 40 | 0.6401 | | | | |
| 138 | D66A | Tv4 | plagioclase | 0.6246 | 64 | 0.7972 | 33.1 | ± | 0.8 | |
| | | | | 0.6221 | 64 | 0.8216 | | | | |
| 139 | D48B | Tv5 | plagioclase | 0.8493 | 64 | 1.000 | 31.2 | ± | 0.7 | |
| | | | | 0.8182 | 60 | 1.039 | | | | |
| 140 | D69C | Tv5 | plagioclase | 0.8109 | 64 | 1.032 | 31.6 | ± | 0.7 | |
| | | | | 0.8322 | 61 | 1.001 | | | | |
| 141 | D48A | Tv5 | plagioclase | 0.5218 | 52 | 0.6993 | 34.3 | ± | 0.8 | |
| | | | | 0.5150 | 51 | 0.6961 | | | | |
| 141 | D48A® | Tv5 | plagioclase | 0.5499 | 56 | 0.6569 | 31.3 | ± | 0.7 | |
| | | | | 0.5490 | 38 | 0.6913 | | | | |
| 142 | D70B | Tv4 | plagioclase | 0.5651 | 42 | 0.7279 | 32.7 | ± | 0.8 | |
| | | | | 0.5554 | 46 | 0.7165 | | | | |
| | | | | 0.5689 | | | | | | |
| 143 | D89B | Tfr | k-felds | 6.590 | 93 | 7.360 | 28.4 | ± | 0.6 | |
| | | | | 6.541 | 92 | 7.219 | | | | |
| 144 | D89A | Tuml | whole rock | 1.097 | 47 | 1.085 | 25.2 | ± | 0.5 | |
| | | | | 1.072 | 38 | 1.050 | | | | |
| 146 | D70D | Tuml | whole rock | 1.357 | 59 | 1.524 | 28.4 | ± | 0.6 | |
| | | | | 1.360 | 57 | 1.498 | | | | |
| 147 | D73H | Tv4 | plagioclase | 0.2967 | 25 | 0.3066 | 30.5 | ± | 0.8 | |
| | | | | 0.3045 | 40 | 0.4123 | | | | |
| 148 | D85A | Tuml | plagioclase | 0.3456 | 3 | 0.4882 | 36.8 | ± | 17.8 | |
| | | | | 0.3493 | 2 | 0.2664 | | | | |
| | | | | | 5 | 0.7518 | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×10$^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 149 | D76B | Tfr | k-felds | 6.126 | 91 | 6.664 | 27.8 | ± | 0.6 | 2 |
| | | | | 6.160 | 93 | 6.716 | | | | |
| 150 | D76A | Tuml | whole rock | 1.224 | 54 | 1.242 | 26.1 | ± | 0.5 | |
| | | | | 1.193 | 53 | 1.231 | | | | |
| 151 | D78B | Tfr | k-felds | 6.558 | 93 | 7.076 | 27.5 | ± | 0.6 | 2 |
| | | | | 6.598 | | | | | | |
| 152 | D75A | Tv4 | plagioclase | 0.5836 | 52 | 0.7659 | 32.0 | ± | 1.8 | |
| | | | | 0.5966 | 44 | 0.6938 | | | | |
| | | | | | 37 | 0.7639 | | | | |
| 153 | D75B | Tv4 | plagioclase | 0.7325 | 55 | 0.8160 | 28.4 | ± | 0.7 | |
| | | | | 0.7430 | 45 | 0.8234 | | | | |
| 155 | J-140 | Tfr | k-felds | 7.203 | 93 | 7.696 | 27.4 | ± | 0.6 | 2 |
| | | | | 7.182 | 88 | 7.802 | | | | |
| | | | | 7.132 | 97 | 7.617 | | | | |
| 157 | D53D | Tuml | whole rock | 1.258 | 41 | 1.368 | 27.1 | ± | 0.5 | 2 |
| | | | | 1.268 | 41 | 1.316 | | | | |
| 158 | J-212 | Tv4 | k-felds | 6.053 | 95 | 7.807 | 32.6 | ± | 0.7 | 2 |
| | | | | 6.018 | 91 | 7.629 | | | | |
| 160 | J-369 | Tv5 | plagioclase | 0.9264 | 46 | 1.124 | 30.6 | ± | 0.8 | 2 |
| | | | | 0.9072 | 45 | 1.073 | | | | |
| | | | | | 54 | 1.104 | | | | |
| 161 | D62A | Tv5 | plagioclase | 0.3583 | 25 | 0.4555 | 32.4 | ± | 0.9 | 2 |
| | | | | 0.3688 | 30 | 0.4675 | | | | |
| | | | | 0.3623 | | | | | | |
| 162 | D62B | Tv5 | plagioclase | 0.5073 | 25 | 0.6385 | 31.5 | ± | 0.9 | 2 |
| | | | | 0.5152 | 29 | 0.6254 | | | | |
| 163 | J-375 | Tv3 | plagioclase | 1.858 | 84 | 2.675 | 36.6 | ± | 1.1 | 2 |
| | | | | 1.807 | 72 | 2.573 | | | | |
| | | | | 1.822 | | | | | | |
| 164 | W-300 | Tv3 | plagioclase | 0.3394 | 27 | 0.4404 | 35.3 | ± | 2.2 | 2 |
| | | | | 0.3382 | 33 | 0.4997 | | | | |
| | | | | | 25 | 0.4662 | | | | |
| 166 | W-204 | Tuml | plagioclase | 0.2172 | 10 | 0.1756 | 26.0 | ± | 4.6 | |
| | | | | 0.2168 | 17 | 0.2018 | | | | |
| | | | | | 24 | 0.2489 | | | | |
| | | | | | 11 | 0.2578 | | | | |
| 167 | W-173 | Ti | biotite | 6.081 | 77 | 8.821 | 37.2 | ± | 0.6 | 2 |
| | | | | 5.977 | 75 | 8.792 | | | | |
| 169 | WD-8 | Tv5 | plagioclase | 1.070 | 60 | 1.243 | 30.0 | ± | 0.7 | 2 |
| | | | | 1.059 | 56 | 1.263 | | | | |
| 170 | W-200 | Tv5 | k-felds | 5.371 | 92 | 6.274 | 29.7 | ± | 0.6 | 2 |
| | | | | 5.376 | 89 | 6.245 | | | | |
| 171 | WF-1 | Tv5 | k-felds | 5.796 | 94 | 7.024 | 31.0 | ± | 1.2 | 2 |
| | | | | 5.822 | 79 | 7.340 | | | | |
| | | | | | 93 | 6.826 | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×10$^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 175 | I-521 | Tv4 | k-felds | 3.742 | 83 | 4.715 | 31.4 | ± | 0.7 | 2 |
| | | | | 3.770 | 85 | 4.523 | | | | |
| 176 | I-532 | Tuml | plagioclase | 1.248 | 44 | 1.583 | 30.4 | ± | 1.9 | 2 |
| | | | | 1.282 | 49 | 1.409 | | | | |
| | | | | 1.289 | 47 | 1.555 | | | | |
| 180 | I-470 | Tv4 | k-felds | 5.571 | 89 | 7.783 | 35.1 | ± | 0.8 | 2 |
| | | | | 5.699 | 92 | 7.732 | | | | |
| 182 | DZ 31 | Tv6 | k-felds | 3.315 | 85 | 3.983 | 29.7 | ± | 1.2 | 2 |
| | | | | 3.347 | 76 | 3.763 | | | | |
| 183 | I-494 | Tv4 | biotite | 7.180 | 83 | 9.493 | 33.7 | ± | 0.5 | 2 |
| | | | | 7.176 | 85 | 9.503 | | | | |
| 183 | I-494 | Tv4 | plagioclase | 0.8973 | 36 | 1.350 | 35.5 | ± | 4.0 | 2 |
| | | | | | 31 | 1.151 | | | | |
| 184 | I-478 | Tv4 | k-felds | 6.440 | 90 | 8.244 | 31.5 | ± | 1.0 | 2 |
| | | | | 6.605 | 91 | 7.819 | | | | |
| | | | | | 92 | 8.105 | | | | |
| 185 | I-164 | Tv4 | k-felds | 3.194 | 83 | 4.035 | 31.7 | ± | 0.7 | 2 |
| | | | | 3.257 | 79 | 3.989 | | | | |
| 186 | HF-1 | Tuml | plagioclase | 0.4904 | 52 | 0.5936 | 32.8 | ± | 1.9 | 2 |
| | | | | 0.4979 | 36 | 0.6572 | | | | |
| | | | | | 37 | 0.6549 | | | | |
| 187 | VG-7B | Tv4 | k-felds | 4.517 | 83 | 5.722 | 33.0 | ± | 1.0 | 2 |
| | | | | 4.510 | 85 | 5.964 | | | | |
| 188 | CM634 | Tv4? | k-felds | 2.593 | 71 | 3.095 | 31.7 | ± | 1.2 | 2 |
| | | | | 2.530 | 67 | 3.159 | | | | |
| | | | | 2.437 | | | | | | |
| 189 | CM449 | Tuml | whole rock | 2.025 | 77 | 2.389 | 29.8 | ± | 0.6 | 2 |
| | | | | 2.027 | 77 | 2.347 | | | | |
| 190 | PLM | Tuml | plagioclase | 0.7055 | 60 | 0.9655 | 31.3 | ± | 3.0 | 2 |
| | | | | 0.7200 | 50 | 0.8049 | | | | |
| | | | | | 44 | 0.8504 | | | | |
| 194 | PC-1 | Tuml | whole rock | 2.595 | 74 | 3.232 | 31.8 | ± | 0.6 | 2 |
| | | | | | 77 | 3.235 | | | | |
| 195 | Ni 30 | Tv6 | plagioclase | 0.7223 | 73 | 0.8855 | 30.9 | ± | 0.7 | 2 |
| | | | | 0.7295 | 59 | 0.8746 | | | | |
| 196 | BTVbl | Tv1 | plagioclase | 1.003 | 58 | 1.648 | 41.6 | ± | 1.0 | 2 |
| | | | | 1.017 | 65 | 1.654 | | | | |
| 197 | PER | Tv1 | plagioclase | 0.5086 | 48 | 0.7975 | 42.3 | ± | 2.4 | 2 |
| | | | | 0.5070 | 45 | 0.8424 | | | | |
| | | | | | 40 | 0.8907 | | | | |
| 198 | J-ER | Tv4 | k-felds | 5.008 | 88 | 6.751 | 33.5 | ± | 0.8 | 2 |
| | | | | 5.026 | 83 | 6.459 | | | | |
| | | | | | 80 | 6.590 | | | | |

(*continued*)

TABLE 5. K-Ar AGES (*continued*)

| # | Sample | Unit | Mineral | %K | %40*Ar | 40*Ar ×10$^{-6}$ scc/gm | Age (Ma) | | ±1σ | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| 201 | CG-BL | Tv2 | k-felds | 6.479 | 94 | 9.146 | 37.2 | ± | 1.1 | 2 |
| | | | | 6.409 | 93 | 9.667 | | | | |
| | | | | | 95 | 9.390 | | | | |
| 204 | CH88-16 | KTi | hornblende | 0.2798 | 77 | 0.6702 | 59.3 | ± | 1.2 | 2 |
| | | | | 0.2871 | 61 | 0.6579 | | | | |
| 207 | RED | Tv1 | biotite | 7.137 | 86 | 11.27 | 40.6 | ± | 0.6 | 2 |
| | | | | 7.088 | 89 | 11.42 | | | | |
| 207 | RED | Tv1 | k-felds | 7.388 | 95 | 11.37 | 39.7 | ± | 0.9 | 2 |
| | | | | 7.317 | 96 | 11.56 | | | | |
| 208 | RP | Tv4 | k-felds | 5.653 | 91 | 7.484 | 33.1 | ± | 0.7 | 2 |
| | | | | 5.682 | 90 | 7.220 | | | | |
| 209 | SC11-9 | Tv4 | k-felds | 5.570 | 94 | 7.617 | 33.3 | ± | 1.8 | 2 |
| | | | | 5.657 | 86 | 6.882 | | | | |
| | | | | | 89 | 7.500 | | | | |
| 210 | SC11-10 | Tv4 | k-felds | 5.164 | 93 | 6.707 | 33.3 | ± | 0.7 | 2 |
| | | | | 5.077 | 89 | 6.661 | | | | |
| 211 | EC1 | Tv4 | k-felds | 5.594 | 88 | 7.396 | 34.8 | ± | 1.1 | 2,4 |
| | | | | 5.645 | 86 | 7.846 | | | | |
| | | | | | 89 | 7.783 | | | | |
| 212 | ECD | Tuml | whole rock | 1.642 | 67 | 1.917 | 30.5 | ± | 0.6 | 2,4 |
| | | | | 1.628 | 68 | 1.995 | | | | |
| 214 | RND1 | Tv4 | k-felds | 6.111 | 94 | 8.201 | 34.5 | ± | 0.7 | 2,4 |
| | | | | 6.196 | 89 | 8.454 | | | | |
| 215 | TTV | Tv4 | biotite | 6.752 | 84 | 9.033 | 34.4 | ± | 0.5 | 2.4 |
| | | | | 6.665 | 78 | 9.046 | | | | |
| 215 | TTV | Tv4 | k-felds | 2.483 | 65 | 3.544 | 34.9 | ± | 1.4 | 2,4 |
| | | | | 2.472 | 86 | 3.302 | | | | |
| | | | | | 72 | 3.339 | | | | |
| 216 | TTD | Tv4 | k-felds | 6.212 | 95 | 8.276 | 34.6 | ± | 1.9 | 2,4 |
| | | | | 6.281 | 93 | 9.018 | | | | |
| | | | | | 96 | 8.165 | | | | |
| 217 | 4EN1 | Tv4 | k-felds | 4.804 | 87 | 6.232 | 33.0 | ± | 0.7 | 2,4 |
| | | | | 4.703 | 83 | 6.059 | | | | |
| 218 | 4MPB | Tuml | whole rock | 1.053 | 59 | 1.340 | 32.9 | ± | 0.7 | 2,4 |
| | | | | 1.048 | 59 | 1.374 | | | | |
| 220 | CLLD | Tv4 | plagioclase | 1.013 | 66 | 1.245 | 31.5 | ± | 0.7 | 2,4 |
| | | | | 1.007 | 65 | 1.249 | | | | |
| 221 | OWLD | Tv4 | k-felds | 5.844 | 89 | 7.551 | 33.8 | ± | 1.2 | 2,4 |
| | | | | 5.834 | 73 | 8.067 | | | | |
| | | | | | 95 | 7.629 | | | | |
| 223 | XYZB | Tuml | whole rock | 1.586 | 57 | 1.911 | 31.2 | ± | 0.6 | 2,4 |
| | | | | 1.583 | 58 | 1.964 | | | | |

*Note:* References (Ref.): 1—Wark et al. (1990); 2—McDowell and Mauger (1994); 3—Swanson and McDowell (1985); 4—Megaw and McDowell (1983). k-felds—sanidine-anorthoclase. Decay constants are from Steiger and Jäger (1977).

references listed. The analytical techniques used have remained essentially identical to those described in McDowell and Keizer (1977). Analytical uncertainties are stated at one sigma. On Figures 2A–2C, the ages are shown without error bars in stratigraphic order for each column.

Within the main Sierra Madre Occidental (Fig. 2A) , the K-Ar ages for the major ignimbrites range from 38 to 28 Ma, with a younger group at ca. 23 Ma (Tv7) that is limited to the western part of area 1. Ignimbrites belonging to transect units Tv4, Tv5, and Tv6 appear to be the most prominent across the entire main Sierra Madre Occidental. The older units (Tv1–3) are present but effectively blanketed by younger ignimbrites. Ages published recently in Swanson et al. (2006) suggest that rocks belonging to Tv6 become more prominent toward the south of Tomochic in the Copper Canyon area. For the upper mafic lavas (Tuml), there is one age of 30 Ma (columns 3 and 4), and ages from 25 to 18 Ma in column 1W, where the lavas are intercalated with felsic units of Tv7.

Within central Chihuahua (Figs. 2B and 2C) K-Ar ages for the major ignimbrites range from 41 Ma to 30 Ma. Age group Tv4 is prominent across the entire area, whereas group Tv5 appears to be represented irregularly. Units belonging to Tv6 appear to be present only locally. Although the older groups are distinct locally, their importance at regional scale is difficult to evaluate because of the extensive cover of ignimbrites of unit Tv4. Ignimbrites between 40 and 45 Ma in age are more prominent east and north of Chihuahua City (McDowell and Mauger, 1994). The ferroaugite rhyolites (Tfr) are distinctly younger (K-Ar ages ca. 27.5 Ma) and are intercalated with the upper mafic lavas (Tuml), for which measured ages are generally from 32 to 30 Ma (eastern side) and 28 to 26 Ma on the west.

## Uranium-Lead Zircon Ages

Table 6 lists data for four U-Pb zircon age determinations that have been previously published and discussed (McDowell and Mauger, 1994). The concordia diagrams and interpretations are given in that reference. The results provided an age of 60 Ma for one intrusive from the KTi unit, 43 Ma for each of two samples from unit Tv1, and 36 Ma for a sample from unit Tv3. These ages provide important data for the older portions of the volcanic sections, from which samples suitable for K-Ar dating have been difficult to obtain.

## $^{40}Ar$-$^{39}Ar$ Ages

Table 7 lists (from west to east) forty-four $^{40}Ar$-$^{39}Ar$ age determinations of sanidine and anorthoclase from samples within the map area. These ages were obtained well after the field investigations had been completed either from the archive of samples prepared for K-Ar dating, or from new mineral separations from coarser crush fractions of those samples. The measurements were made at the New Mexico Geochronology Research Laboratory in Socorro. Two separate modes of laser-fusion analyses were performed. The original K-Ar mineral separates were too fine for single grain fusions. In such cases, each fusion aliquot typically consisted of ~50 grains. These multiple grain measurements are indicated by M in Table 7. More recent measurements were made by fusion of single grains (S) isolated from the coarser fractions. In both types of experiment, individual laser-fusion results that were statistically different, older (suggesting the presence of xenocrysts) and younger (suggesting the presence of altered grains), were excluded from the age calculations. Some samples contained appreciable plagioclase as phenocrysts; results from individual fusions with calculated K/Ca < 1 were excluded as well. Appendix Tables 3A and 3B, and Appendix Figures 1A and 1B provide more complete results. Further information on analytical procedures and a discussion of the superiority of the single-grain measurements for ignimbrites are given in McDowell et al. (2005). All ages are normalized to an age of 28.02 Ma for sanidine from the Fish Canyon Tuff.

TABLE 6. U-Pb ZIRCON AGES

| # | Sample | Unit | Fraction | Wt. (mg) | Ages (Ma) and 2σ uncertainties: $^{206}Pb/^{204}Pb$ | $^{206}Pb/^{238}U$ | $^{207}Pb/^{235}U$ | $^{207}Pb/^{206}Pb$ | Interpreted age |
|---|---|---|---|---|---|---|---|---|---|
| 156 | J-406 | Tv1 | nm6,m2,c. | 13.9 | 817.3 | 43.0 ± 0.2 | 43.7 ± 0.4 | 85 ± 18.5 | 43 ± 1 Ma |
| | | | nm6,m2,f. | 4.7 | 665.7 | 43.3 ± 0.2 | 43.8 ± 0.3 | 71.5 ± 8 | |
| | | | nm2,c. | 15.3 | 750.2 | 42.8 ± 0.2 | 43.0 ± 0.3 | 50 ± 9 | |
| 165 | CUSI | Tv3 | nm2,f. | 15.4 | 165.2 | 36.0 ± 0.2 | 35.9 ± 0.6 | 31 ± 37 | 36 ± 1 Ma |
| | | | m2,nm5,c. | 14.1 | 172.1 | 36.3 ± 0.2 | 36.2 ± 0.5 | 29.5 ± 34 | |
| | | | nm2,c. | 22.4 | 144.3 | 37.0 ± 0.2 | 38.7 ± 0.7 | 143.5 ± 40 | |
| 204 | CH88-16 | KTi | nm10,m5 | 4.9 | 363.7 | 78.0 ± 0.4 | 94.6 ± 0.5 | 537 ± 4 | 60 ± 3 Ma |
| | | | nm5,m3 | 6.8 | 1595 | 68.9 ± 0.3 | 77.4 ± 0.5 | 348 ± 8.5 | |
| | | | nm3,c. | 17.4 | 764.4 | 79.7 ± 0.4 | 95.8 ± 1.1 | 510 ± 23 | |
| | | | nm-2.5,c. | 9.1 | 2095 | 68.7 ± 0.3 | 75.7 ± 0.4 | 305 ± 3 | |
| 206 | CH88-13 | Tv1 | m6 | 3.6 | 674.0 | 45.5 ± 0.2 | 45.5 ± 0.3 | 66 ± 10.5 | 43 ± 2.5 Ma |
| | | | nm4,m2.5 | 4.3 | 498.8 | 41.1 ± 0.2 | 42.2 ± 0.4 | 103.5 ± 18.5 | |

*Note*: Complete data and concordia plots are given in McDowell and Mauger (1994); m—magnetic; nm—nonmagnetic; f—fine; c—coarse; mg—milligram. Decay constants are from Steiger and Jäger (1977).

TABLE 7. Ar-Ar AGES

| # | Sample | Unit | Technique | N/Nt | K/Ca ± 2σ | MSWD | Age ± 2σ |
|---|---|---|---|---|---|---|---|
| 11 | 11-15-1 | Tv4 | S | 14/14 | 76.4 ± 9.8 | 2.9 | 33.33 ± 0.07 |
| 17 | 3-25-4 | Tv6 | S | 8/11 | 1.8 ± 2.2 | 2.8 | 28.09 ± 0.31 |
| 18 | 10-20-1 | Tv4 | S | 14/15 | 71.7 ± 17.9 | 2.2 | 33.42 ± 0.06 |
| 52 | P18A | Tv6 | M | 8/8 | 8.1 ± 1.7 | 1.5 | 28.89 ± 0.08 |
| 57 | S-27 | Tv4 | S | 13/15 | 76.6 ± 13.4 | 0.7 | 33.41 ± 0.04 |
| 58 | S-14 | Tv6 | S | 26/15 | 17.5 ± 15.8 | 2.6 | 28.74 ± 0.07 |
| 66 | N-09 | Tv6 | S | 29/30 | 11.6 ± 3.8 | 2.3 | 28.73 ± 0.05 |
| 67 | S-22 | Tv2 | S | 10/15 | 47.5 ± 19.6 | 2.9 | 39.23 ± 0.11 |
| 109 | S-4 | Tv5 | S | 7/51 | 36.0 ± 65.1 | 1.1 | 32.01 ± 0.13 |
| 109 | S-4 | Tv5 | M | 6/6 | 1.3 ± 0.2 | 0.7 | 32.55 ± 0.10 |
| 113 | S-6 | Tv3 | S | 9/30 | 45.7 ± 9.6 | 1.6 | 35.06 ± 0.08 |
| 119 | S-31 | Tv5 | M | 6/6 | 1.1 ± 0.2 | 0.4 | 31.91 ± 0.09 |
| 120 | S-32 | Tv6 | S | 26/27 | 45.3 ± 9.1 | 1.8 | 31.38 ± 0.05 |
| 131 | C-12 | Tv5 | S | 2/30 | 71.9 ± 24.1 | 0.8 | 33.22 ± 0.18 |
| 132 | C-7 | Tv4 | S | 15/15 | 77.8 ± 12.2 | 1.7 | 33.33 ± 0.05 |
| 143 | D89B | Tfr | S | 14/15 | 107.0 ± 21.4 | 0.5 | 29.76 ± 0.05 |
| 149 | D76B | Tfr | M | 9/9 | 104.4 ± 30.1 | 0.8 | 29.87 ± 0.08 |
| 151 | D78B | Tfr | S | 15/15 | 109.7 ± 23.3 | 1.5 | 29.78 ± 0.05 |
| 155 | J-140 | Tfr | M | 10/11 | 70.8 ± 20.3 | 0.8 | 29.86 ± 0.08 |
| 158 | J-212 | Tv4 | S | 14/15 | 177.2 ± 53.7 | 1.6 | 35.09 ± 0.07 |
| 158 | J-212 | Tv4 | M | 10/10 | 140.8 ± 84.0 | 6 | 35.09 ± 0.16 |
| 163 | J-375 | Tv3 | S | 15/15 | 2.4 ± 1.5 | 0.6 | 36.04 ± 0.24 |
| 169 | WD-8 | Tv5 | S | 7/18 | 20.5 ± 10.3 | 0.8 | 32.42 ± 0.09 |
| 170 | W-200 | Tv5 | M | 10/10 | 29.8 ± 5.3 | 1.2 | 32.79 ± 0.09 |
| 171 | WF-1 | Tv5 | M | 10/10 | 30.5 ± 4.5 | 2.5 | 32.70 ±0.12 |
| 175 | I-521 | Tv4 | M | 8/8 | 6.5 ± 1.5 | 2.4 | 33.19 ± 0.14 |
| 180 | I-470 | Tv4 | M | 7/8 | 680.2 ± 537.2 | 4.5 | 34.7 ± 0.2 |
| 182 | DZ-31 | Tv6 | M | 7/10 | 4.5 ± 0.5 | 4.8 | 29.91 ± 0.17 |
| 184 | I-478 | Tv4 | M | 9/9 | 21.3 ± 5.0 | 0.3 | 33.92 ± 0.09 |
| 185 | I-164 | Tv4 | M | 10/10 | 4.9 ± 1.2 | 2 | 33.14 ± 0.10 |
| 187 | VG-7B | Tv4 | M | 10/10 | 19.8 ± 3.4 | 0.8 | 35.43 ± 0.09 |
| 188 | CM634 | Tv4? | M | 8/10 | 4.6 ± 0.4 | 3.3 | 33.59 ± 0.22 |
| 198 | J-ER | Tv4 | M | 6/6 | 42.2 ± 6.1 | 0.7 | 35.19 ± 0.10 |
| 201 | CG-BL | Tv2 | M | 7/8 | 22.4 ± 4.8 | 1.4 | 37.71 ± 0.12 |
| 207 | RED | Tv1 | M | 9/9 | 11.3 ± 18.5 | 1.1 | 40.85 ± 0.13 |
| 208 | RP | Tv4 | M | 10/10 | 8.7 ± 4.6 | 0.5 | 34.05 ± 0.09 |
| 209 | SC11-9 | Tv4 | M | 10/10 | 43.9 ± 7.5 | 1.8 | 35.29 ± 0.10 |
| 210 | SC11-10 | Tv4 | M | 8/8 | 14.4 ± 1.7 | 2.8 | 35.59 ± 0.19 |
| 211 | EC1 | Tv4 | M | 9/9 | 97.3 ± 46.3 | 0.6 | 35.15 ± 0.09 |
| 214 | RND1 | Tv4 | M | 10/10 | 18.5 ± 2.0 | 0.9 | 34.87 ± 0.09 |
| 215 | TTV | Tv4 | M | 10/10 | 2.5 ± 0.6 | 1.6 | 34.26 ± 0.12 |
| 217 | 4EN1 | Tv4 | S | 15/15 | 21.0 ± 4.9 | 0.8 | 33.10 ± 0.08 |
| 220 | CLLD | Tv4 | S | 15/15 | 28.0 ± 4.8 | 2.1 | 33.71 ± 0.08 |
| 221 | OWLD | Tv4 | S | 10/16 | 15.1 ± 6.4 | 0.5 | 33.74 ± 0.07 |

*Note*: N—number of extractions used for age calculation; Nt—total number of extractions. M—multigrain analysis, S—single grain analysis. Results normalized to an age of 28.02 Ma for Fish Canyon sanidine. MSWD—mean square of weighted deviate.

The improved precision of the $^{40}Ar$-$^{39}Ar$ ages reveals a significantly refined picture of the history of activity across the Sierra Madre Occidental volcanic field. It is apparent that the intervals from 32.5 to 34.25 Ma and 35.0 to 35.5 Ma were very active episodes of ignimbrite volcanism within the map area. Although it cannot be argued that the sample distribution is uniform or representative, ignimbrites with ages from 33 to 34 Ma occur across the entire width of the map, and are not restricted to a single or closely related group of sources. Another aspect of the data is the comparison of $^{40}Ar$-$^{39}Ar$ ages with K-Ar ages for feldspars from the same samples. In almost all cases, uncertainties of the K-Ar measurements at two sigma overlap with the corresponding $^{40}Ar$-$^{39}Ar$ ages. Nevertheless, there appears to be a distinct bias toward younger K-Ar ages. The most extreme case for this effect is with comparison of the ages for the ferroaugite rhyolites (unit Tfr). The four available $^{40}Ar$-$^{39}Ar$ ages cluster very tightly at 29.82 ± 0.05 Ma, which is more than 2 Ma higher than the corresponding K-Ar ages (27.5–28.4 Ma). This bias illustrates a problem first raised by Webb and McDougall (1967) and documented by McDowell (1983). Those authors showed that it is very difficult to obtain experimental conditions adequate to completely extract radiogenic argon from high-temperature feldspars or their melts. The superior results of $^{40}Ar$-$^{39}Ar$ dating have been used to refine the assignment of the original map units to transect unit groupings in some cases. Further discussion of this $^{40}Ar$-$^{39}Ar$ data set is reserved for future publications.

## ISOTOPIC DATA

A small amount of radiogenic and oxygen isotope data has been obtained for samples from within the transect (Table 8). Virtually all of these data have been published (Wark, 1991; McDowell et al., 1999; Housh and McDowell, 2005). Analytical techniques and discussion of the data are given fully in those references. Generally, the radiogenic isotope results indicate that a variable degree of (lower) crustal input was involved in generating all of the measured rocks. Housh and McDowell (2005) used a geographically wider data set to examine the nature of the basement contribution and to propose crustal domains for the largely concealed basement of northwestern Mexico.

## DISCUSSION

It should be evident that this map covers a very small portion of the area of the Sierra Madre Occidental volcanic field. Even after adding all of the isolated and scattered projects completed at UT and by other groups, probably less than 10% of the field has been surveyed. Progress toward better field coverage is likely to be slow for several reasons. Access has improved greatly, yet many parts of the Sierra Madre Occidental remain inaccessible and somewhat inhospitable. The cadre of Mexican geoscientists trained in volcanology has increased immensely since this project began, but mostly they are drawn toward the younger Trans-Mexican volcanic belt, where volcanic hazards and population concentrations are greater, and funding opportunities are better. Given these circumstances it is vital that substantial field efforts within the Sierra Madre Occidental volcanic field be published. This attempt will be successful if it promotes enhanced interest in field-based research, and enables those interested to identify critical locations and approaches that will more rapidly expand our knowledge of this tectonically important, yet understudied province. It should therefore be regarded as a “benchmark” for future investigations in the Sierra Madre Occidental volcanic field..

In order to portray field relationships at regional scale, it was necessary to group the map units into an arbitrary scheme. The current version is the third such attempt, but it is the first that has held together across the entire length of the transect area. These groupings are merely units of convenience, even more so than the original map units. The sole criterion for evaluation of the scheme is whether it is useful in portraying the history and patterns of activity across this portion of the Sierra Madre Occidental volcanic field

Inclusion of the voluminous analytical data in this report is critical so that they can be examined in geologic and geographic context. Much has been made of the eastward trend in major-element compositions across the Sierra Madre Occidental, central and eastern Chihuahua, with an implied continuation to the more alkaline volcanic province in Trans-Pecos Texas (McDowell and Clabaugh, 1979; Bramson, 1984). It is clear from the plots included here that the mid-Tertiary volcanic rocks across the Sierra Madre Occidental and central Chihuahua retain a distinct arc signature, and that regional major-element variations are subtle. Detailed scrutiny of trace-element variations (yet to come) should provide a sharper test of regional variations and of the continuity of trends with contemporary rocks in eastern Chihuahua and Texas.

The rapid recurrence of major eruptions in the Sierra Madre Occidental volcanic field relative to the inherent analytical uncertainty and limitations of K-Ar dating of middle Tertiary volcanic rocks dictates that a K-Ar age compilation can only provide an overall range of timing and a statistical peak of maximum activity. It will require high precision $^{40}Ar$-$^{39}Ar$ dating to identify periods of peak intensity within the overall life of the Sierra Madre Occidental volcanic field, to examine the geographic variation of these outbursts throughout the field, and to examine the degree of resonance of the pattern of activity within the Sierra Madre Occidental volcanic field and with broadly contemporary volcanic fields in adjacent areas. The data presented here are just the beginning of the era of application of high-precision geochronology in the Sierra Madre Occidental volcanic field.

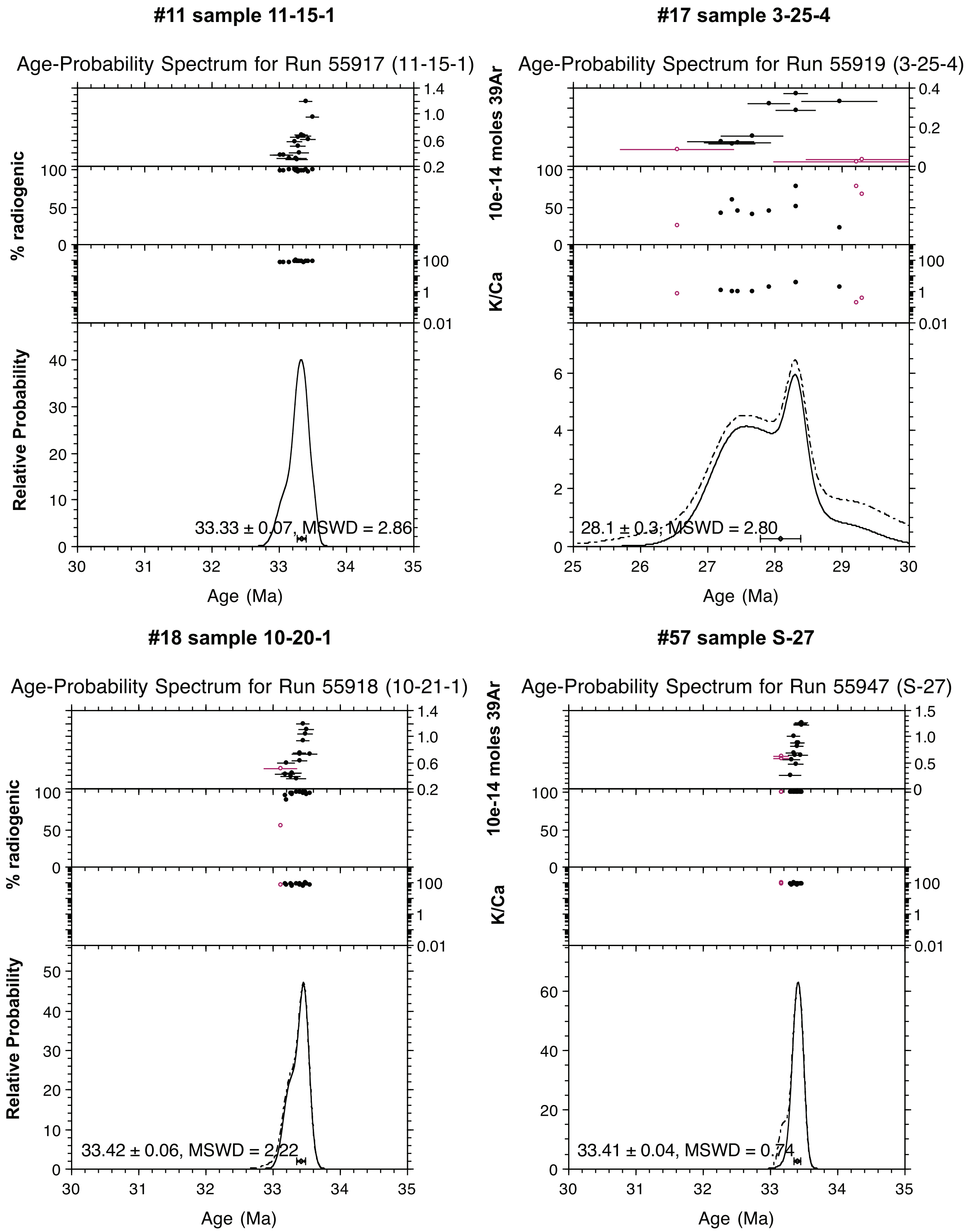
TABLE 8. ISOTOPIC DATA

| # | Sample | Lead isotopes | | | Strontium | Neodymium | εNdi | $\delta^{18}O$ | Ref. |
|---|---|---|---|---|---|---|---|---|---|
| | | 206/204i | 207/204i | 208/204i | 87/86i | 143/144i | | | |
| 2 | 3-21-2 | 18.728 | 15.609 | 38.597 | | | | | 1 |
| 8 | Ma-1 | 18.608 | 15.600 | 38.615 | | | | | 1 |
| 13 | 11-14-1 | 18.636 | 15.579 | 38.506 | | | | | 1 |
| 14 | C-2 | 18.645 | 15.583 | 38.543 | | | | | 1 |
| 16 | C-1 | 18.664 | 15.583 | 38.558 | | | | | 1 |
| 20 | 3-25-3 | 18.638 | 15.596 | 38.607 | | | | | 1 |
| 23 | O59 | | | | 0.7064 | | | | 3 |
| 30 | J22A | | | | 0.7061 | | | | 3 |
| 31 | NV07 | 18.631 | 15.621 | 38.693 | 0.7064 | 0.51246 | –2.7 | 7.7 | 2,3 |
| 33 | O57 | | | | 0.7060 | 0.51247 | –2.3 | | 3 |
| 34 | O58 | | | | 0.7061 | 0.51247 | –2.3 | | 3 |
| 35 | O54 | 18.613 | 15.592 | 38.714 | 0.7070 | 0.51245 | –2.9 | | 2,3 |
| 37 | O53 | | | | 0.7066 | | | | 3 |
| 41 | O38 | 18.493 | 15.581 | 38.788 | 0.7089 | 0.51233 | –5.2 | | 2,3 |
| 44 | 90-25 | 18.631 | 15.594 | 38.675 | 0.70632 | | –2.5 | | 2 |
| 46 | J23 | | | | | 0.51249 | –2.1 | 8.0 | 3 |
| 47 | 90-78 | 18.757 | 15.591 | 38.700 | 0.70584 | | –1.9 | | 2 |
| 49 | 90-80 | | | | 0.70554 | 0.51252 | –1.4 | | |
| 55 | O18 | 18.579 | 15.581 | 38.537 | 0.7056 | | –3.0 | | 2 |
| 60 | 90-69 | 18.795 | 15.588 | 38.689 | 0.70578 | | –1.1 | | 2 |
| 61 | S-17 | | | | 0.7066 | | | | 3 |
| 70 | 90-56 | 18.688 | 15.585 | 38.626 | 0.70572 | | –2.1 | | 2 |
| 71 | M11 | | | | | | | 7.5 | 3 |
| 72 | S-7 | 18.485 | 15.579 | 38.513 | 0.7063 | | –2.1 | 8.4 | 2,3 |
| 75 | 90-15 | 18.625 | 15.571 | 38.450 | 0.70524 | | 0.7 | | 2 |
| 76 | 90-14 | 18.618 | 15.568 | 38.449 | 0.70526 | | 0.5 | | 2 |
| 79 | N68 | | | | 0.7053 | 0.51265 | 1.0 | | 3 |
| 82 | O-04 | | | | | 0.51255 | –0.9 | | 3 |
| 88 | N70 | | | | 0.7051 | 0.51262 | 0.3 | | 3 |
| 89 | 90-97 | 18.695 | 15.584 | 38.540 | 0.70519 | | –0.7 | | 2 |
| 92 | 90-18 | | | | 0.70526 | 0.51273 | 0.6 | | |
| 95 | S-3 | | | | | | | 8.5 | 3 |
| 96 | 90-46 | 18.705 | 15.609 | 38.700 | 0.70667 | | –2.2 | | 2 |
| 97 | 90-63 | 18.754 | 15.593 | 38.633 | 0.70554 | | –0.2 | | 2 |
| 100 | 90-99 | 18.734 | 15.588 | 38.533 | 0.70490 | | –0.5 | | 2 |
| 101 | 86-40 | | | | | | | 7.0 | 3 |
| 105 | 90-101 | 18.741 | 15.598 | 38.563 | 0.70453 | | 0.0 | | 2 |
| 108 | 90-20 | 18.647 | 15.573 | 38.522 | 0.70434 | | 2.0 | | 2 |
| 109 | S-4 | 18.752 | 15.618 | 38.592 | 0.7055 | | 0.5 | | 2,3 |
| 114 | N55 | 18.726 | 15.599 | 38.525 | 0.7053 | 0.51252 | –1.5 | 7.7,7.3 | 2,3 |
| 116 | 90-110 | 18.684 | 15.596 | 38.501 | 0.70481 | | 1.0 | | 2 |
| 118 | N60 | | | | | 0.51262 | 0.5 | 7.6 | 3 |
| 120 | S-32 | | | | 0.7058 | | | 7.7 | 3 |
| 121 | N71 | | | | 0.7044 | 0.51259 | –0.1 | | 3 |
| 123 | 90-112 | 18.641 | 15.590 | 38.449 | 0.70443 | | 2.2 | | 2 |
| 124 | 90-115 | 18.664 | 15.572 | 38.412 | 0.70477 | | 0.9 | | 2 |
| 126 | 90-117 | 18.622 | 15.563 | 38.345 | 0.70461 | | 2.3 | | 2 |
| 127 | C-18 | | | | 0.7059 | | | | 3 |
| 146 | D70D | 18.701 | 15.604 | 38.516 | 0.70517 | 0.51251 | –1.7 | | 1 |
| 150 | D76A | 18.682 | 15.594 | 38.527 | 0.70520 | 0.51262 | 0.3 | | 1 |
| 152 | D75A | 18.843 | 15.650 | 38.716 | | | | | 1 |
| 157 | D53D | 18.772 | 15.619 | 38.547 | 0.70465 | 0.51265 | 1.0 | | 1 |
| 160 | J-369 | 18.769 | 15.597 | 38.530 | | | | | 1 |
| 164 | W-300 | 18.367 | 15.571 | 38.240 | | | | | 1 |
| 170 | W-200 | 18.877 | 15.714 | 38.912 | | | | | 1 |
| 172 | W-176 | 18.718 | 15.593 | 38.415 | 0.70393 | | | | 1 |
| 175 | I-521 | 18.810 | 15.644 | 38.700 | | | | | 1 |
| 176 | I-532 | 18.818 | 15.670 | 38.772 | | | | | 1 |
| 181 | I-133 | 18.498 | 15.577 | 38.325 | 0.70419 | 0.51264 | 0.8 | | 1 |
| 182 | DZ-31 | 18.891 | 15.683 | 38.801 | | | | | 1 |
| 190 | PLM | 18.764 | 15.636 | 38.648 | | | | | 1 |
| 194 | PC-1 | 18.801 | 15.628 | 38.586 | 0.70562 | | | | 1 |
| 197 | PER | 18.728 | 15.644 | 38.628 | | | | | 1 |
| 212 | ECD | 18.249 | 15.541 | 38.167 | 0.70518 | 0.51250 | –2.0 | | 1 |
| 213 | 4RSRB | 18.577 | 15.583 | 38.458 | 0.70515 | 0.51252 | –1.4 | | 1 |
| 214 | RND1 | 18.544 | 15.594 | 38.402 | | | | | 1 |

*Note*: References (Ref.): 1—Housh and McDowell (2005); 2—McDowell et al. (1999); 3—Wark (1991). i—initial isotopic ratio.

A

**Ar-Ar single-grain probability plots - page 1**

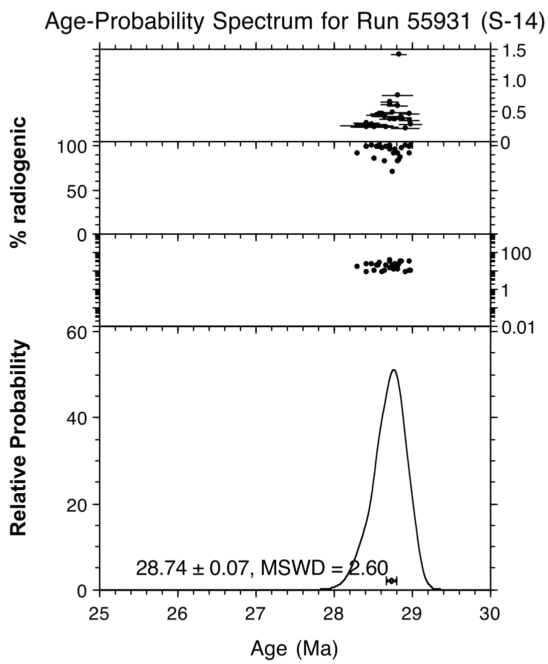



Appendix Figure 1 (*continued on following pages*). (A) Probability plots for single-grain $^{40}Ar$-$^{39}Ar$ measurements. From bottom to top, the plots include: age spectra (in units of relative probability); calculated K/Ca (note log scale); % radiogenic $^{40}Ar$ contents; and, $^{39}Ar$ concentrations (units are $10^{-14}$ moles). Individual analyses that were not included in the cumulative age calculations are shown with unfilled symbols. The diamond symbol with error bar gives the weighted mean and 2σ error limits. (B) Same as A for multi-grain $^{40}Ar$-$^{39}Ar$ measurements.

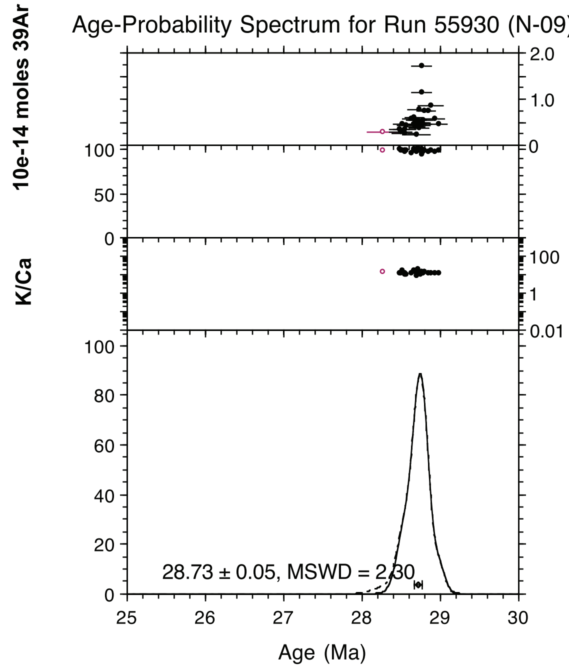
A

**Ar-Ar single-grain probability plots - page 2**

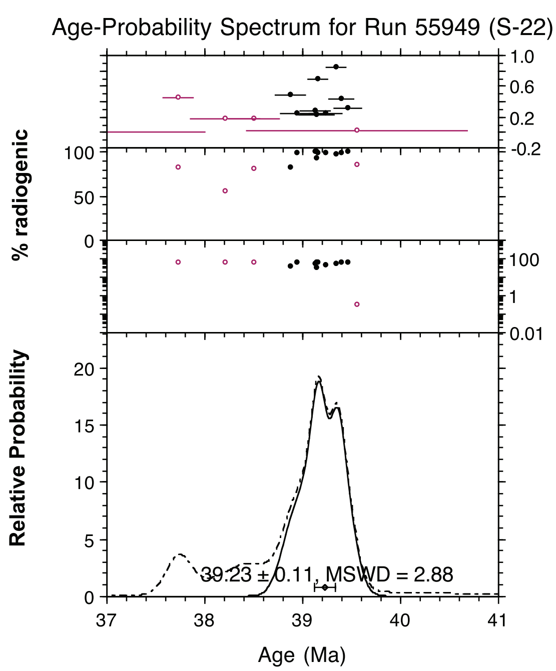
**#58 sample S-14**



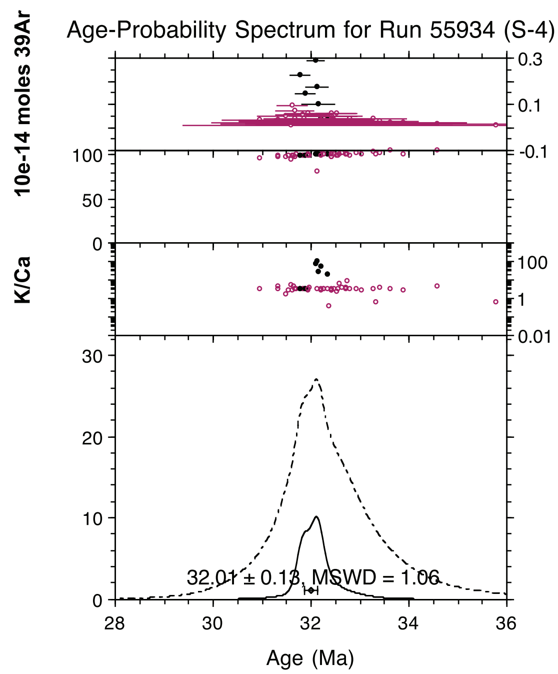

**#66 sample N-09**



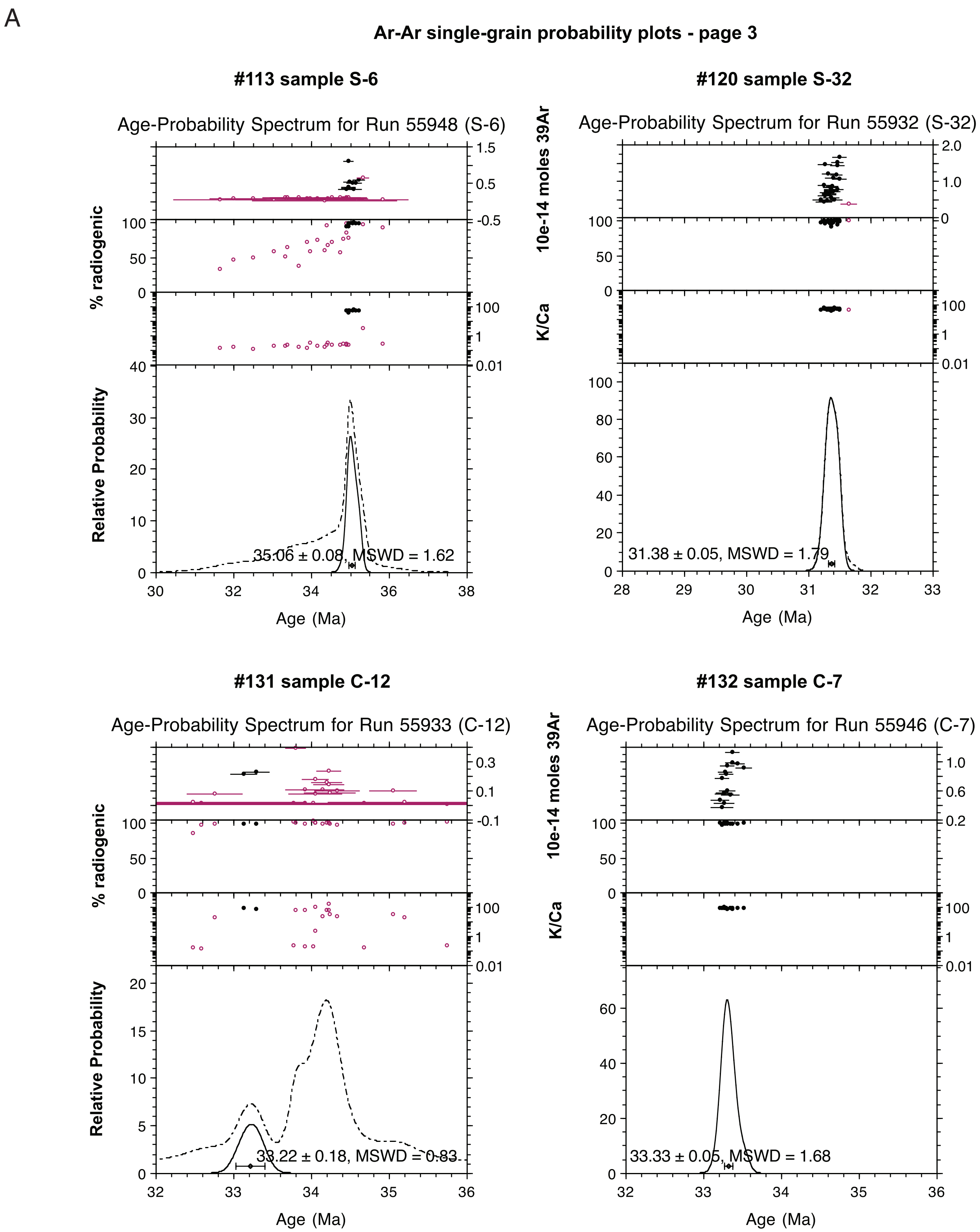

**#67 sample S-22**




**#109 sample S-4**

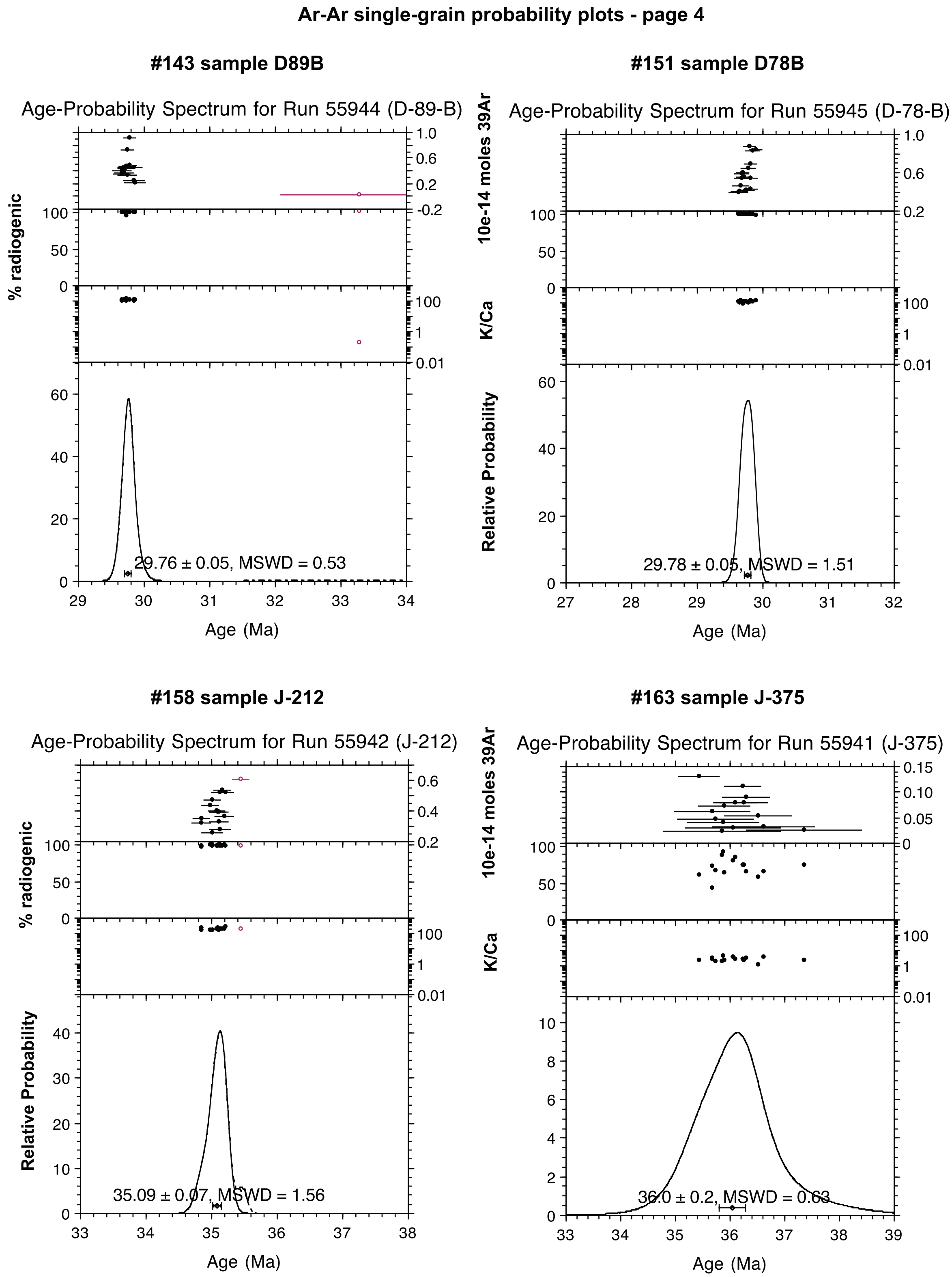



Appendix Figure 1 (*continued*).




Appendix Figure 1 (*continued*).

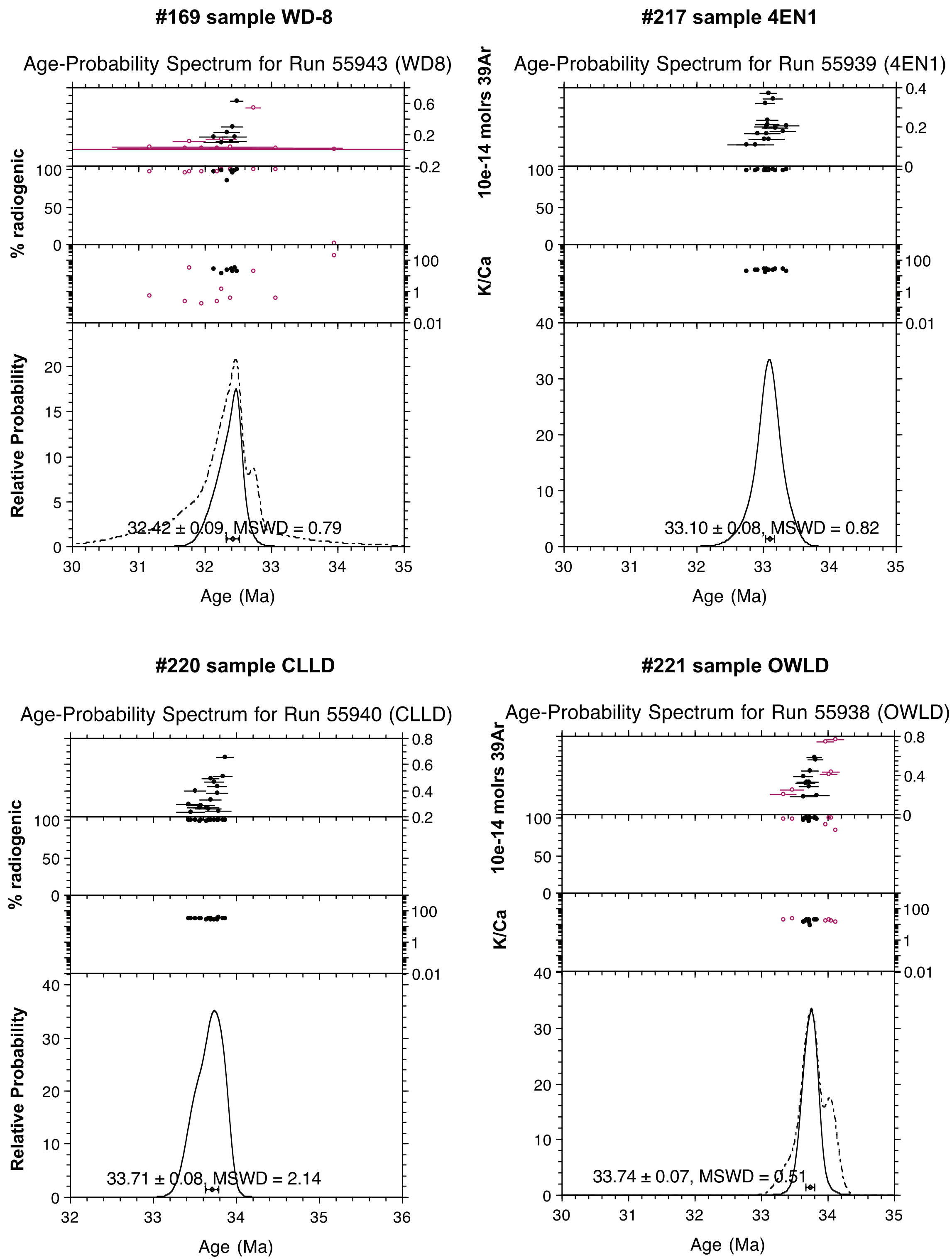
A




Appendix Figure 1 (*continued*).

A

**Ar-Ar single-grain probability plots - page 5**

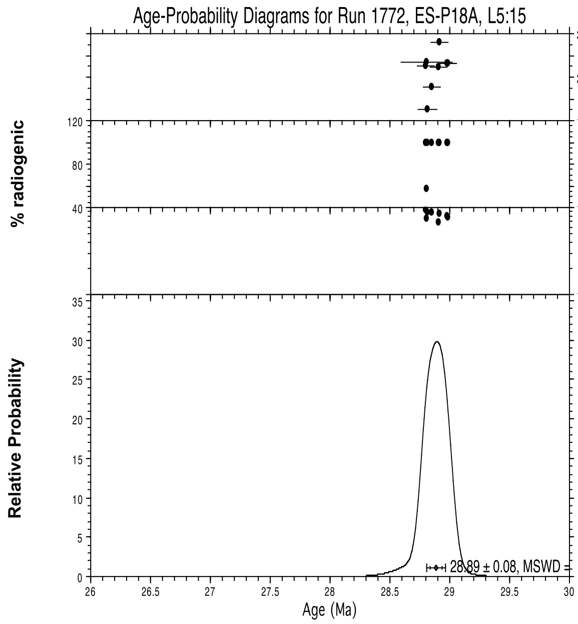



Appendix Figure 1 (*continued*).

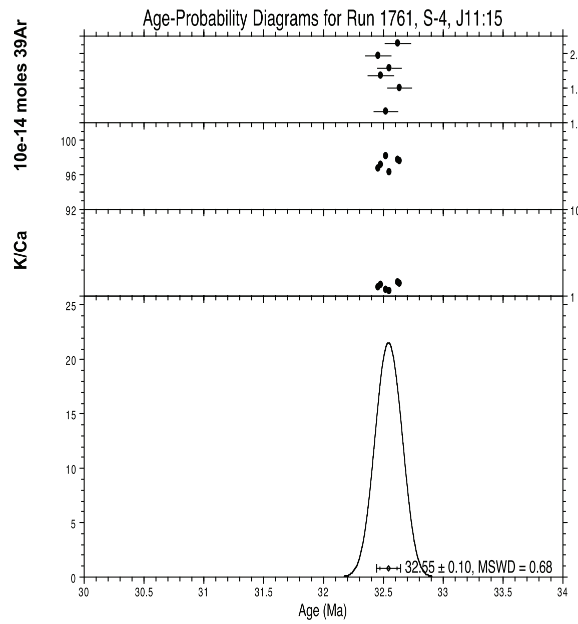
B

**Ar-Ar multi-grain probability plots - page 1**

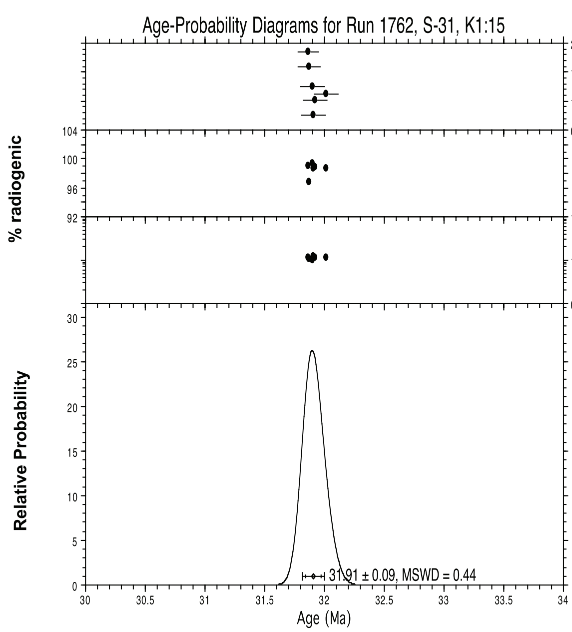
**#52 sample P-18a**



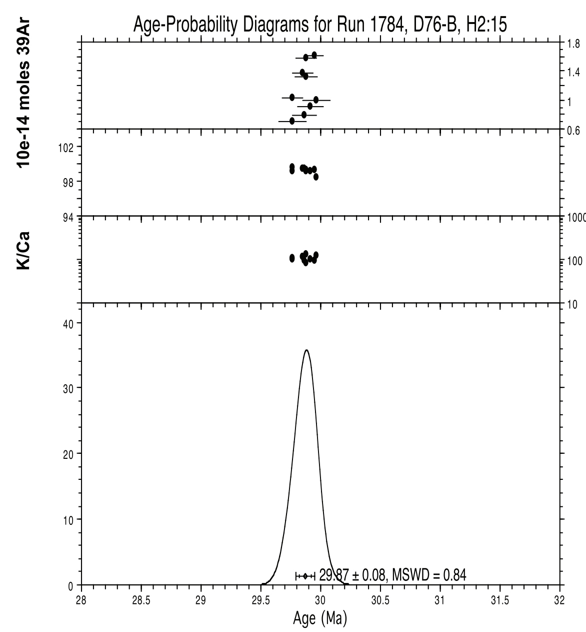

**#109 sample S-4**




**#119 sample S-31**




**#149 sample D76B**

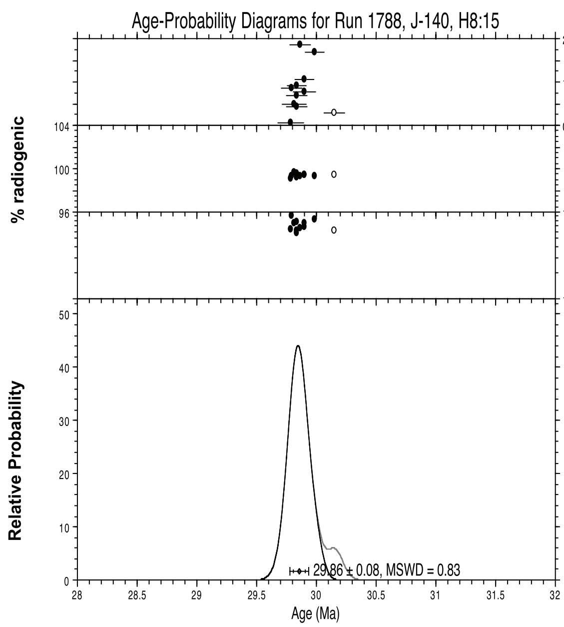



Appendix Figure 1 (*continued*).

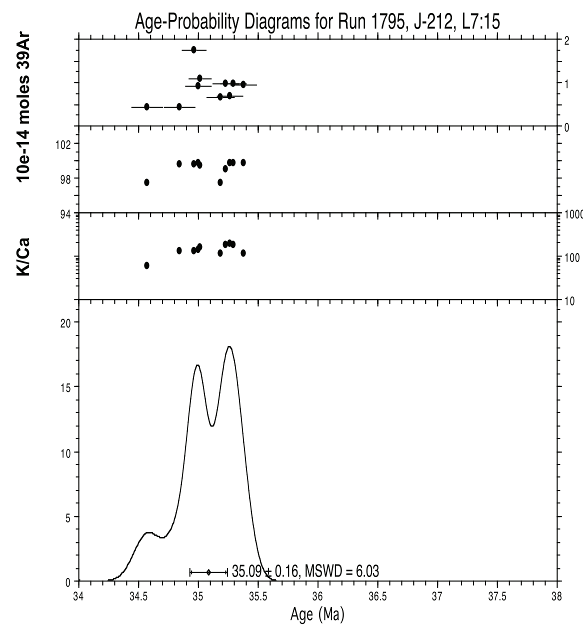
B

## Ar-Ar multi-grain probability plots - page 2

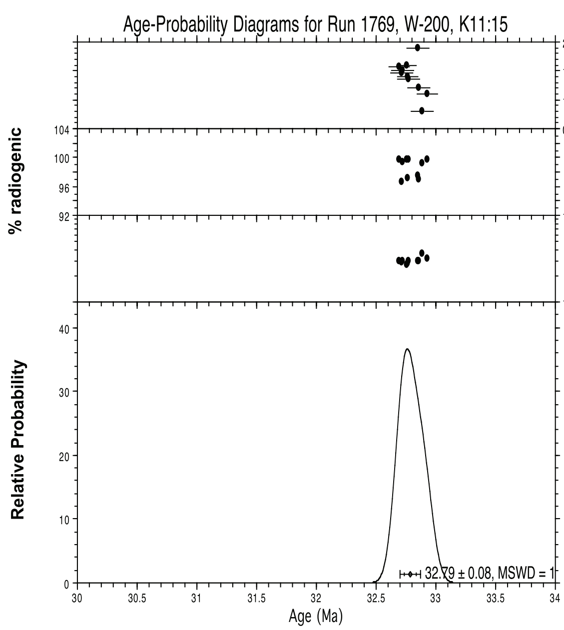
### #155 sample J-140



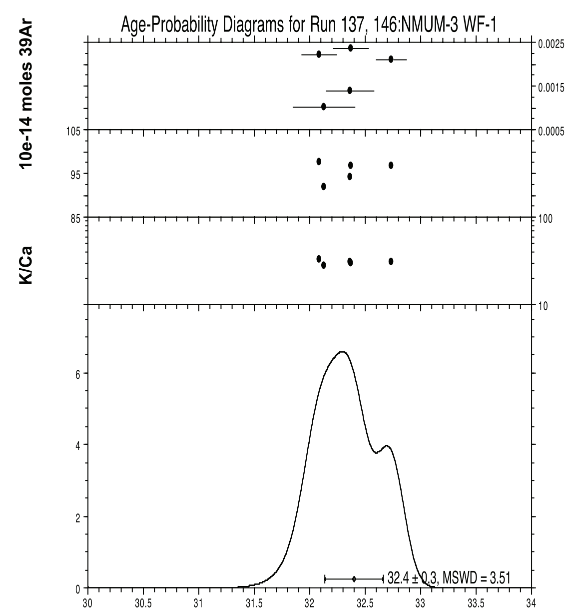

### #158 sample J-158




### #170 sample W-200




### #171 sample WF-1

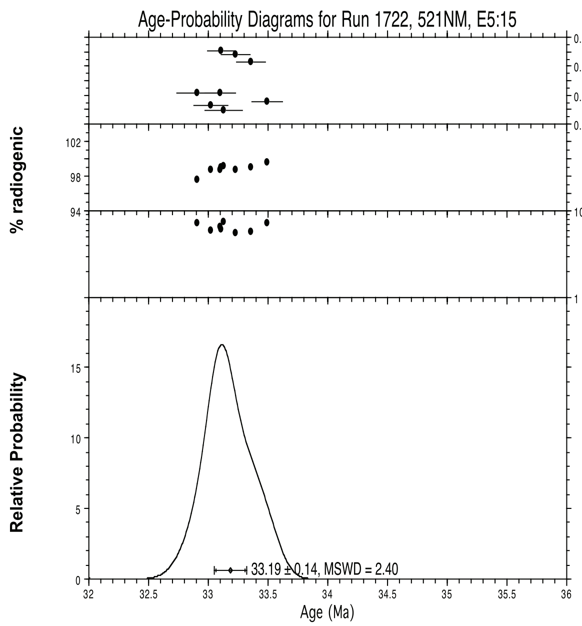



Appendix Figure 1 (*continued*).

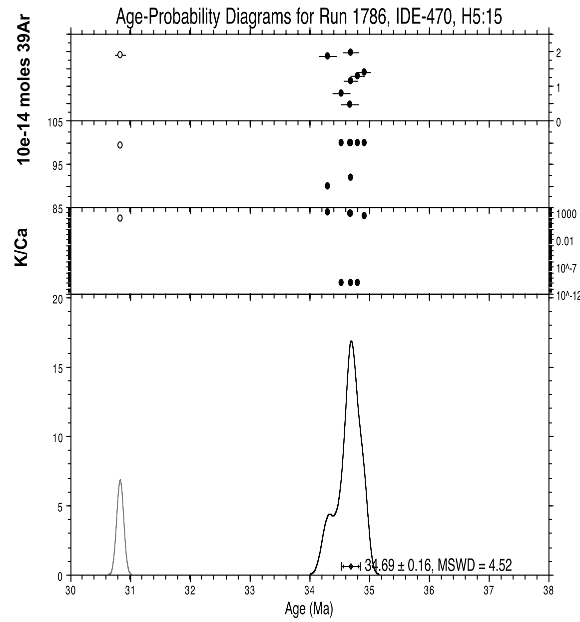
B

## Ar-Ar multi-grain probability plots - page 3

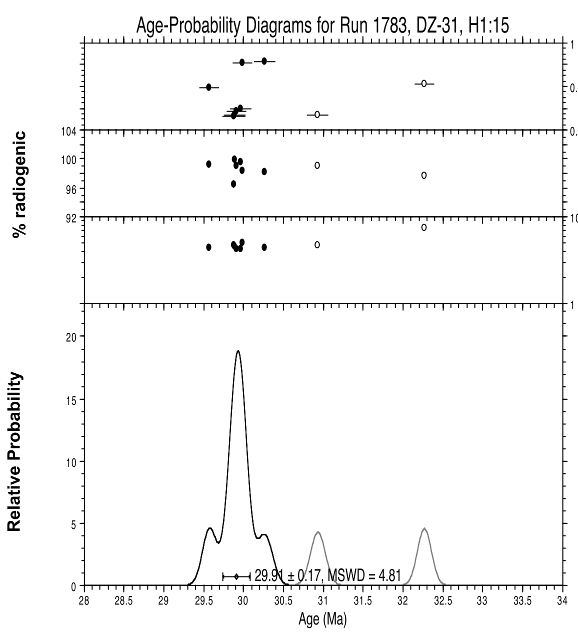
### #175 sample I-521



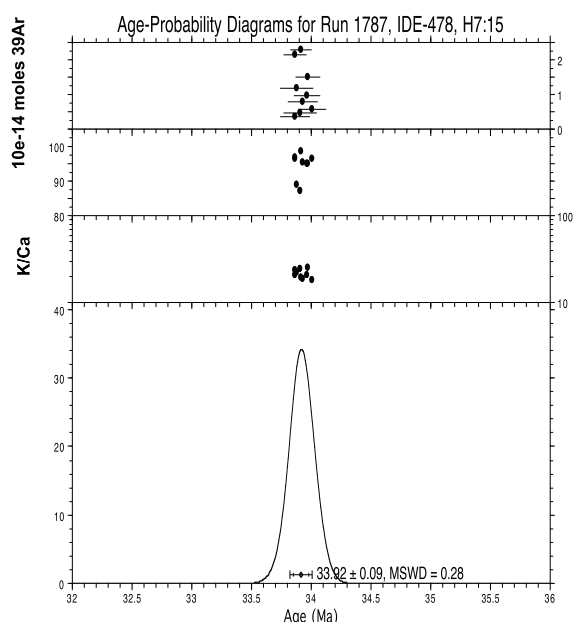

### #180 sample I-470




### #182 sample DZ-31




### #184 sample I-478

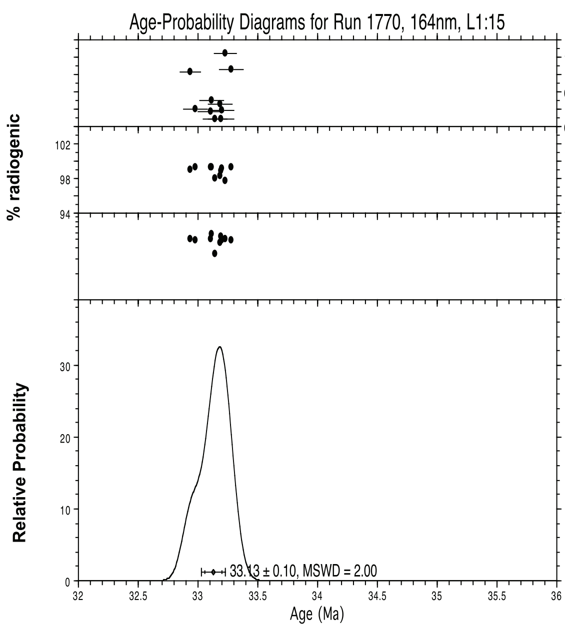



Appendix Figure 1 (*continued*).

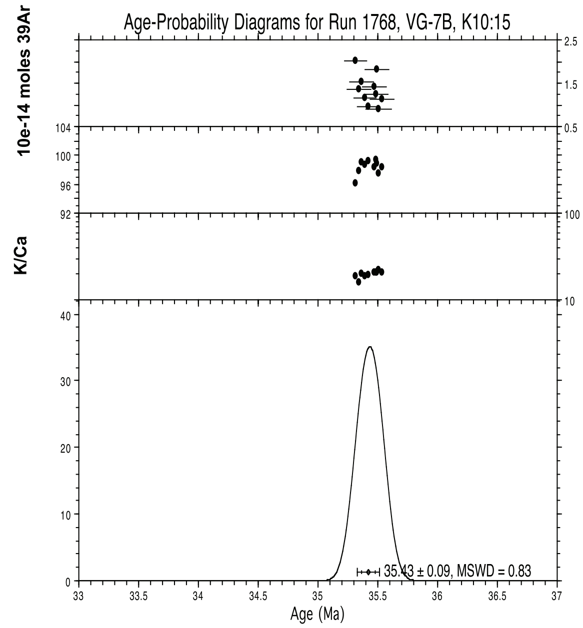
B

## Ar-Ar multi-grain probability plots - page 4

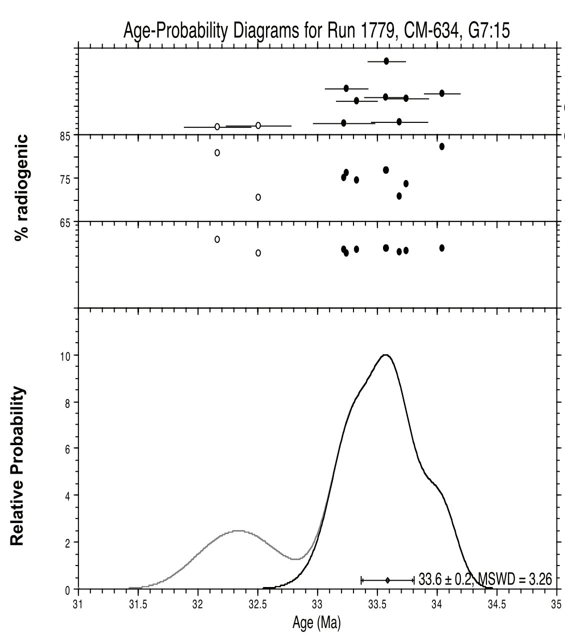
### #185 sample I-164



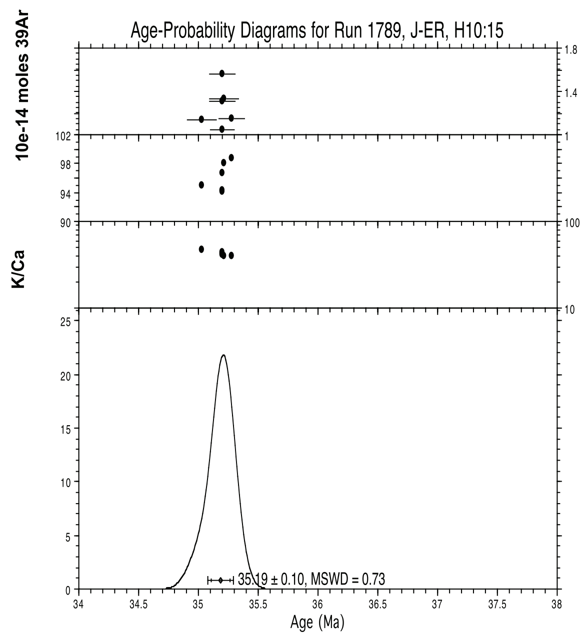

### #187 sample VG-7B




### #188 sample CM634




### #198 sample J-ER

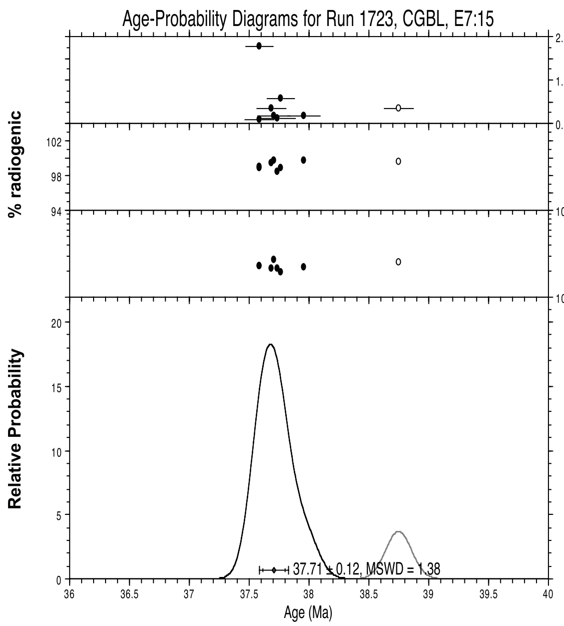



Appendix Figure 1 (*continued*).

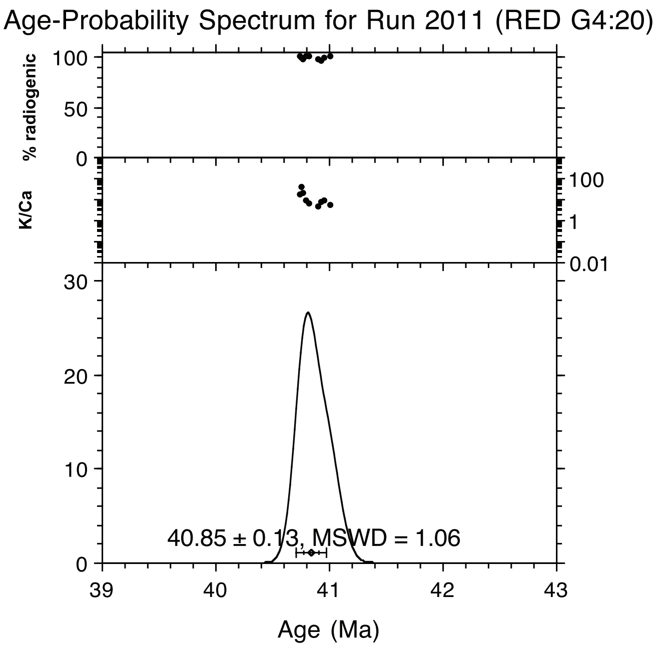
B

**Ar-Ar multi-grain probability plots - page 5**

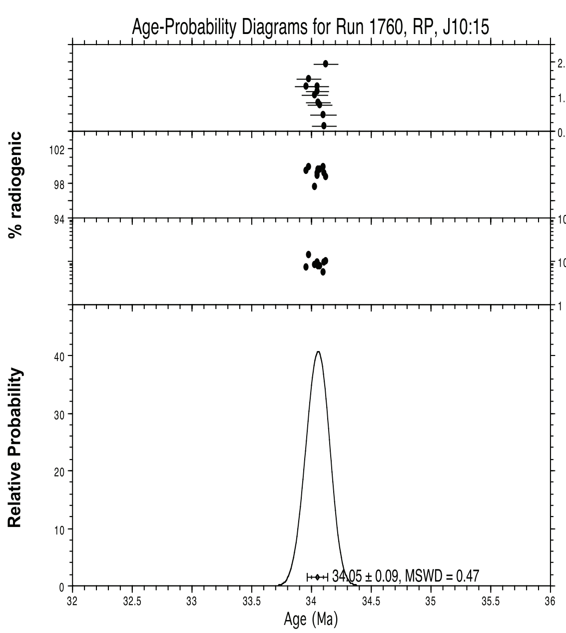
**#201 sample CG-BL**



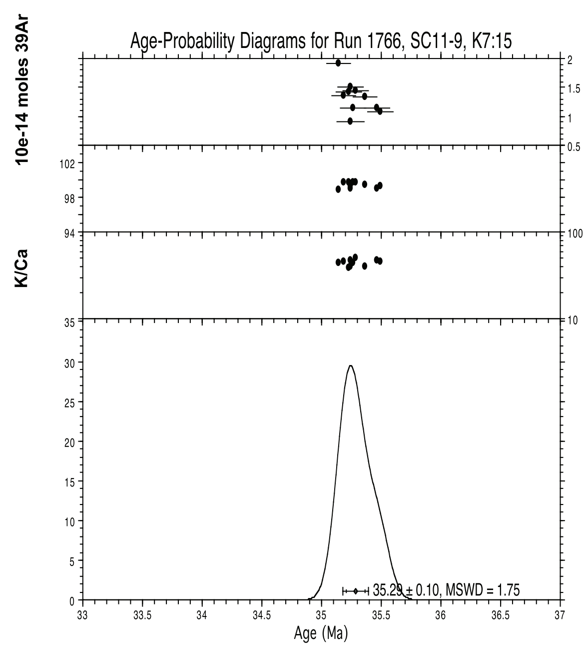

**#207 sample RED**




**#208 sample RP**




**#209 sample SC11-9**

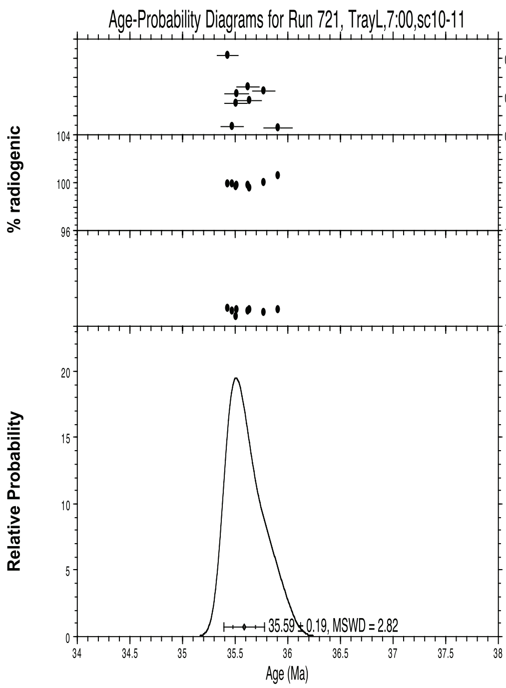



Appendix Figure 1 (*continued*).

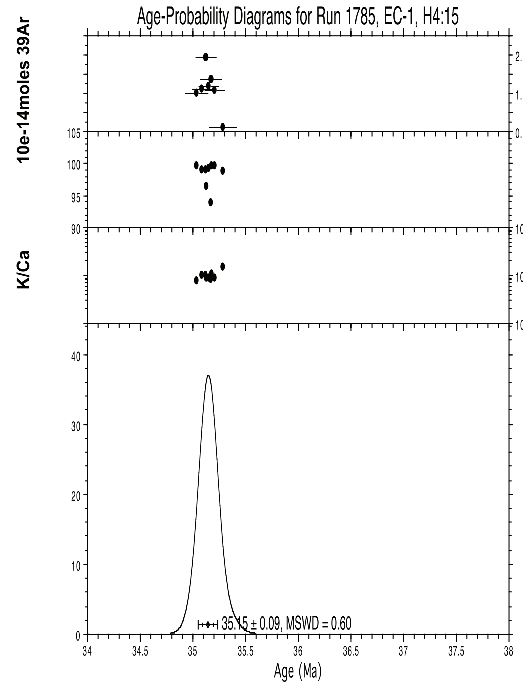
B

## Ar-Ar multi-grain probability plots - page 6

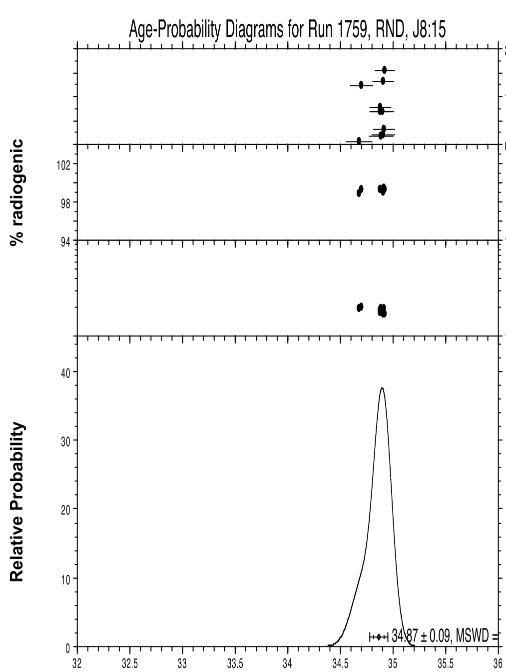
**#210 sample SC11-10**



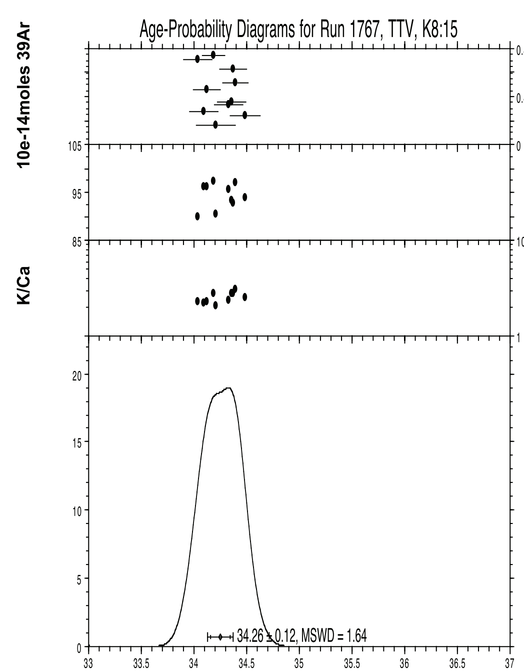

**#211 sample EC1**




**#214 sample RND1**




**#215 sample TTV**




Appendix Figure 1 (*continued*).

APPENDIX TABLE 1. RELATIONSHIP OF LOCAL UNITS TO REGIONAL UNITS

| Unit | Local Units<br>Area 1<br>(Bockoven, 1980) | Area 2<br>(Wark, 1989) | Area 3<br>(Kempter, 1986) | Area 4<br>(Swanson, 1977) |
|---|---|---|---|---|
| Tuml | **Upper andesite; basalt flows** | **Magdalena mafic lavas**; Lagunitas mafic lavas | | |
| Tfr | | | | |
| Tvu | Rhyolite flows and tuffs undivided | rhyolite, undifferentiated | | |
| Tv7 | **Rhyolite tuffs and flows** | | | |
| Tv6 | Atravesado tuff; **Cascada tuff; intrusive rhyolites** | **Cascada tuff; Pinto lavas and tuffs** | El Portrero tuff; **Mofo lavas; Cueva tuff: Tomochic Formation; Pinto lava**; Heredia tuff | **Cueva Formation** |
| Tv5 | | **Rio Verde tuff** | mafic lava flows; **Rio Verde tuff** | **Rio Verde tuff** |
| Tv4 | Aeropista (Vista) tuff | Rancho Viejo hybrid lavas; **Vista tuff** | Rancho Viejo hybrid lavas; Vista tuff | **Vista tuff** |
| Tv3 | | **San Filipe tuff** | **Agueachic lavas: San Filipe tuff** | |
| Tv2 | Andesite agglomerate | Cascabel tuff; Carrizo andesitic lavas | **Cascabel tuff** | |
| Tv1 | | | | |

| Unit | Area 5<br>(Duex, 1983) | Area 6<br>(Stimac, 1983) | Area 7<br>(Wark, 1983) | Area 8<br>(Ide, 1986) |
|---|---|---|---|---|
| Tuml | **50W, 50C, 30C,50E lavas** | Rancho Viejo Formation | Frijol mafic flows | **Trias flow; Buena Vista flow**; Ojo Blanco flows; minor flows |
| Tfr | **40C tuff** | **Frijol tuff** | Frijol tuff | Frijol tuff |
| Tvu | 10E altered mafic lava | | | unidentified felsic and mafic flows |
| Tv7 | | | | |
| Tv6 | | Coyachic rhyolite; Carpa rhyolite; Corcobado flows and tuffs | **Durazno tuffs; Pilares flows** | |
| Tv5 | **10C,20C tuffs; 20E**,30E tuffs; 40E lava | **Caballos flows and tuffs**; Chen-Chen flows; **Yomama tuffs** | Pilares tuffs | Eche tuffs; Bustillo rhyolite dome; **Tambor unit; Buena Vista rhyolite flows**; Alamo tuff |
| Tv4 | 20W,30W,40W tuffs | | | Flores tuff; Laboricita flow; Abajo tuff |
| Tv3 | 10W flows and tuffs | Divisidero Formation; **Loma del Toro Formation** | **Divisadero flows and tuffs; Loma del Toro flows and tuffs** | |
| Tv2 | | | | |
| Tv1 | 5C silicified rhyolite | **Bufa tuffs** | | |

| Unit | Area 9<br>(Conlon, 1985) | Area 10<br>(Cook, 1990) | Area 11<br>(Megaw, 1979) | |
|---|---|---|---|---|
| Tuml | **Santa Rosa flows** | Ojo Blanco flows; San Ramon flows | **San Ramon Basalt flows** | |
| Tfr | | Frijol tuff | | |
| Tvu | | | | |
| Tv7 | | | | |
| Tv6 | **Durazno rhyolite flows; Santa Rosalia tuff** | | | |
| Tv5 | **Tambor tuff** | Tambor tuff | | |
| Tv4 | **Rancho de Pena tuff**; Los Fierros tuff; **Jacales tuff**; Vicente Guerero unit | **Palomas tuff** | Moncayo unit; **East Side unit**; Cerro Grande unit; Nuevo tuff; **Sierra Pastorias caldera units; Soto unit; Santa Eulalia capping unit** | |
| Tv3 | | | | |
| Tv2 | **Cerro Grande tuff**; Lajas flow; basal flows | | | |
| Tv1 | | **Perales flows; Canada de Gato flows; Sepulveda unit**; Cuervo unit; **Chivato tuff** | | |

*Note:* Units dated in specific areas are shown in boldface.

APPENDIX TABLE 2. SAMPLE INFORMATION

| # | Sample | Collector | Unit | Local unit | Latitude | Longitude | Major elements | Trace elements | K-Ar | Ar-Ar | Isotopes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-21-3 | Bockoven | Tuml | mafic lava flow | 28.35537 | –108.86954 | M1 | T1,T2 | wr | | |
| 2 | 3-21-2 | Bockoven | Tv7 | felsic lava flow | 28.35724 | –108.86108 | M1 | T1,T2 | bi,pl | | Pb |
| 3 | 3-20-3 | Bockoven | Tuml | intermed lava flow | 28.33037 | –108.71191 | M1 | T1 | | | |
| 4 | 3-20-4 | Bockoven | Tv7 | ash-flow tuff | 28.33034 | –108.70936 | | | pl | | |
| 5 | 12-13-3 | Bockoven | Tuml | mafic lava flow | 28.23810 | –108.69108 | | | pl | | |
| 6 | 3-20-1 | Bockoven | Tuml | mafic lava flow | 28.41057 | –108.68580 | M1 | T1,T2 | | | |
| 7 | 11-16-2 | Bockoven | Tuml | mafic dike | 28.38537 | –108.65523 | | | wr | | |
| 8 | Ma-1 | Bockoven | KTi | Maicova granodiorite | 28.38694 | –108.64767 | M1 | T1 | bi | | Pb |
| 9 | 12-11-4 | Bockoven | Tuml | mafic lava flow | 28.20602 | –108.62801 | | | | | |
| 10 | 12-11-13 | Bockoven | Tvu | intermed. lava flow | 28.15054 | –108.60556 | M1 | T1 | | | |
| 11 | 11-15-1 | Bockoven | Tv4 | ash-flow tuff | 28.39933 | –108.60551 | | | bi,san | S | |
| 12 | 11-16-4 | Bockoven | Tv4 | ash-flow tuff | 28.40262 | –108.59197 | | | bi,san | | |
| 13 | 11-14-1 | Bockoven | Tvu | intermed. agglomerate | 28.43426 | –108.56550 | M1 | T1 | pl | | Pb |
| 14 | C-2 | Swanson | Tvu | intermed. lava flow | 28.19779 | –108.42556 | | | wr,pl | | Pb |
| 15 | 10-23-5 | Bockoven | Tvu | felsic flow-dome | 28.43871 | –108.35149 | M1 | T1,T2 | | | |
| 16 | C-1 | Swanson | Tv6 | felsic flow-dome | 28.19318 | –108.32299 | | | bi,pl | | Pb |
| 17 | 3-25-4 | Bockoven | Tv6 | Cascada tuff | 28.24413 | –108.28233 | | | bi | S | |
| 18 | 10-20-1 | Bockoven | Tv4 | Vista tuff* | 28.34465 | –108.27092 | | | bi,pl | S | |
| 19 | BV5 | Bockoven | Tvu | felsic intrusive | 28.34854 | –108.26691 | M1 | T1,T2 | bi | | |
| 20 | 3-25-3 | Bockoven | Tvu | intermediate lava flow | 28.27785 | –108.25994 | | | pl | | Pb |
| 21 | 3-23-1 | Bockoven | Tuml | intermediate lava flow | 28.35499 | –108.24769 | M1 | T1,T2 | pl | | |
| 22 | 10-25-2 | Bockoven | Tv4 | Vista tuff* | 28.45895 | –108.21755 | M1 | T1 | | | |
| 23 | O59 | Wark (PhD) | Tv6 | Cascada tuff | 28.16867 | –108.20935 | | | pl | | Sr |
| 24 | C-4 | Swanson | Tv6 | felsic flow-dome | 28.21867 | –108.18396 | | | bi,pl | | |
| 25 | 90-29 | Wark (PhD) | Tv2 | intermediate lava flow | 28.20709 | –108.13312 | M3 | T3 | | | |
| 26 | C-6 | Swanson | Tv6 | felsic flow-dome? | 28.20325 | –108.13236 | | | bi,pl,am | | |
| 27 | J22B | Wark (PhD) | Tv2 | intermediate lava flow | 28.21136 | –108.12790 | | | pl | | |
| 28 | NV11 | Wark (PhD) | Tv4 | Vista tuff | 28.51525 | –108.12747 | M1 | T1,T5 | | | |
| 29 | NV01 | Wark (PhD) | Tv4 | Vista tuff | 28.50579 | –108.12747 | M1 | T1,T5 | | | |
| 30 | J22A | Wark (PhD) | Tv2 | intermediate lava flow | 28.21210 | –108.12699 | | | pl | | Sr |
| 31 | NV07 | Wark (PhD) | Tv4 | Vista tuff | 28.50766 | –108.12597 | M1 | T1,T5 | | | Pb,Sr,Nd,O |
| 32 | 90-30 | Wark (PhD) | Tv2 | intermediate lava flow | 28.21182 | –108.12593 | M3 | T3 | | | |
| 33 | O57 | Wark (PhD) | Tv2 | intermediate lava flow | 28.20820 | –108.10584 | M1 | T1,T5 | | | Sr,Nd |
| 34 | O58 | Wark (PhD) | Tv2 | intermediate lava flow | 28.20155 | –108.10115 | M1 | T1 | | | Sr,Nd |
| 35 | O54 | Wark (PhD) | Tuml | Magdalena lava flow | 28.18860 | –108.07473 | M1 | T1 | | | Pb,Sr,Nd |
| 36 | O72 | Wark (PhD) | Tvu | felsic lava flow | 28.29676 | –108.07267 | M1 | T1,T5 | | | |
| 37 | O53 | Wark (PhD) | Tuml | Magdalena lava flow | 28.19609 | –108.06713 | M1 | T1,T5 | | | Sr |
| 38 | O52 | Wark (PhD) | Tuml | Magdalena lava flow | 28.19441 | –108.06668 | M1 | T1 | | | |
| 39 | C-21 | Swanson | Tv4 | Vista tuff* | 28.27956 | –108.05963 | M1 | T1 | pl | | |
| 40 | O48 | Wark (PhD) | Tuml | Magdalena lava flow | 28.19917 | –108.04882 | M1 | T5 | | | |
| 41 | O38 | Wark (PhD) | Tuml | Magdalena lava flow | 28.22744 | –108.04480 | M1 | T1,T5 | | | Pb,Sr,Nd |
| 42 | O39 | Wark (PhD) | Tuml | Magdalena lava flow | 28.22641 | –108.04364 | M1 | T1,T5 | | | |
| 43 | O46 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.21546 | –108.03250 | M1 | | | | |
| 44 | 90-25 | Wark (PhD) | Tv2 | felsic lava flow | 28.34201 | –108.03165 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 45 | J18 | Wark (PhD) | Tv2 | intermediate lava flow | 28.35618 | –108.02025 | | | pl | | |
| 46 | J23 | Wark (PhD) | Tv6 | moat rhyolite flow | 28.33529 | –108.01445 | | | pl | | Nd,O |
| 47 | 90-78 | Wark (PhD) | Tv2 | intermediate lava flow | 28.13855 | –108.01423 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 48 | 90-79 | Wark (PhD) | Tv2 | intermediate lava flow | 28.13908 | –108.00988 | M3 | T3,T4 | | | |
| 49 | 90-80 | Wark (PhD) | Tv2 | intermediate lava flow | 28.14011 | –108.00354 | M3 | T3,T4 | | | Sr,Nd |
| 50 | O23 | Wark (PhD) | Tv6 | moat rhyolite flow | 28.26647 | –107.98503 | M1 | T1,T5 | | | |
| 51 | C-20 | Swanson | Tv6 | Cascada tuff* | 28.35214 | –107.96925 | | | pl | | |
| 52 | P18A | Swanson | Tv6 | Pinto lava flow | 28.31800 | –107.96763 | M1 | | san | M | |
| 53 | N45 | Wark (PhD) | Tv2 | intermediate lava flow | 28.17012 | –107.96299 | M1 | T1 | | | |
| 54 | C-19 | Swanson | Tv4 | Vista tuff* | 28.44111 | –107.96260 | M1 | T1 | pl | | |
| 55 | O18 | Wark (PhD) | Tv6 | Pinto lava flow | 28.27973 | –107.96216 | M1 | T1,T5 | san | | Pb,Sr,Nd |
| 56 | O15 | Wark (PhD) | Tv6 | Pinto lava flow | 28.27862 | –107.95071 | M1 | T1 | | | |
| 57 | S-27 | Kempter | Tv4 | Vista tuff | 28.46482 | –107.94857 | | | san | S | |
| 58 | S-14 | Kempter | Tv6 | Pinto lava flow | 28.28773 | –107.94700 | | | san | S | |
| 59 | O13 | Wark (PhD) | Tv6 | Pinto lava flow | 28.28250 | –107.94262 | M1 | T1,T5 | | | |
| 60 | 90-69 | Wark (PhD) | Tv2 | intermediate lava flow | 28.11018 | –107.93536 | M3 | T3,T4 | | | Pb,Sr,Nd |

(*continued*)

APPENDIX TABLE 2. SAMPLE INFORMATION (*continued*)

| # | Sample | Collector | Unit | Local unit | Latitude | Longitude | Major elements | Trace elements | K-Ar | Ar-Ar | Isotopes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | S-17 | Kempter | Tv3 | San Filipe tuff | 28.18212 | –107.93317 | | | bi,pl | | Sr |
| 62 | 90-73 | Wark (PhD) | Tv2 | intermediate lava flow | 28.06882 | –107.93051 | M3 | T3,T4 | | | |
| 63 | O33 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.56392 | –107.89421 | M1 | T1 | | | |
| 64 | O-06 | Wark (PhD) | Tv6 | Pinto lava flow | 28.31271 | –107.88684 | M1 | T1,T5 | | | |
| 65 | N-07 | Wark (PhD) | Tv6 | Pinto lava flow | 28.31687 | –107.88400 | M1 | T1,T5 | | | |
| 66 | N-09 | Wark (PhD) | Tv6 | Pinto lava flow | 28.31484 | –107.88296 | M1 | T1,T5 | san | S | |
| 67 | S-22 | Kempter | Tv2 | Cascabel tuff | 28.08912 | –107.85776 | M2 | T2 | bi | S | |
| 68 | 90-54 | Wark (PhD) | Tv2 | mafic lava flow | 28.21822 | –107.85588 | M3 | T3 | | | |
| 69 | 90-53 | Wark (PhD) | Tv2 | mafic lava flow | 28.22234 | –107.85417 | M3 | T3,T4 | | | |
| 70 | 90-56 | Wark (PhD) | Tv2 | mafic lava flow | 28.21352 | –107.85320 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 71 | M11 | Kempter | Tuml | Magdalena lava flow | 28.24171 | –107.84906 | | | wr | | O |
| 72 | S-7 | Kempter | Tv6 | moat rhyolite flow | 28.25496 | –107.84782 | M1 | T1 | bi,san | | Pb,Sr,Nd,O |
| 73 | S-19 | Kempter | Tv3 | San Filipe tuff | 28.13296 | –107.84664 | | | bi,pl | | |
| 74 | 90-52 | Wark (PhD) | Tv2 | mafic lava flow | 28.21352 | –107.84615 | M3 | T3 | | | |
| 75 | 90-15 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39668 | –107.82243 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 76 | 90-14 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39731 | –107.82143 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 77 | 90-93 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39597 | –107.82141 | M3 | T3 | | | |
| 78 | 90-12 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39785 | –107.82027 | M3 | T3,T4 | | | |
| 79 | N68 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39732 | –107.81927 | M1 | T1,T5 | | | Sr,Nd |
| 80 | S-9 | Kempter | Tv3 | Agueachic lava flow | 28.28895 | –107.81809 | | | bi,pl | | |
| 81 | N66 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39557 | –107.81493 | | T5 | | | |
| 82 | O-04 | Wark (PhD) | Tv3 | San Filipe tuff | 28.33713 | –107.81021 | M1 | T1,T5 | | | Sr,Nd |
| 83 | 90-11 | Wark (PhD) | Tv3 | San Filipe tuff | 28.39465 | –107.81016 | M3 | T3,T4 | | | |
| 84 | N53 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.37342 | –107.80822 | M1 | T1,T5 | | | |
| 85 | 90-9 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.37394 | –107.80762 | M3 | T3,T4 | | | |
| 86 | N65 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39526 | –107.80719 | | T5 | | | |
| 87 | W-60 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39798 | –107.80630 | | T5 | | | |
| 88 | N70 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38762 | –107.80260 | M1 | T1,T5 | | | Sr,Nd |
| 89 | 90-97 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.41834 | –107.80082 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 90 | 90-19 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39174 | –107.80057 | M3 | T3,T4 | | | |
| 91 | 90-85 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39736 | –107.80046 | M3 | T3,T4 | | | |
| 92 | 90-18 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.38803 | –107.79990 | M3 | T3,T4 | | | Sr,Nd |
| 93 | 90-60 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.11517 | –107.79828 | M3 | T3,T4 | | | |
| 94 | 90-6 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.36542 | –107.79603 | M3 | T3,T4 | | | |
| 95 | S-3 | Kempter | Tv3 | San Filipe tuff | 28.32160 | –107.79593 | M2 | T2 | bi,pl | | O |
| 96 | 90-46 | Wark (PhD) | Tv2 | intermediate lava flow | 28.20057 | –107.79535 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 97 | 90-63 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.11148 | –107.79467 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 98 | 90-64 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.11602 | –107.79457 | M3 | T3,T4 | | | |
| 99 | 90-4 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.35844 | –107.79408 | M3 | T3,T4 | | | |
| 100 | 90-99 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.40795 | –107.79080 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 101 | 86-40 | Wark (PhD) | Tv4 | Vista lava flow | 28.32415 | –107.78906 | M1 | T1,T5 | | | O |
| 102 | N58 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.32404 | –107.78756 | | T1,T5 | | | |
| 103 | N62 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.32363 | –107.78699 | | T5 | | | |
| 104 | S-8 | Kempter | Tv4 | Vista lava flow | 28.31578 | –107.78464 | | | bi,san | | |
| 105 | 90-101 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.40357 | –107.78329 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 106 | 90-21 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.39785 | –107.78205 | M3 | T3,T4 | | | |
| 107 | 90-100 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.40010 | –107.78073 | M3 | T3,T4 | | | |
| 108 | 90-20 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.39757 | –107.77802 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 109 | S-4 | Kempter | Tv5 | Rio Verde tuff | 28.34764 | –107.77466 | | | san | S,M | Pb,Sr,Nd |
| 110 | 90-2 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39296 | –107.76501 | M3 | T3,T4 | | | |
| 111 | 90-106 | Wark (PhD) | Tv4 | Rancho Viejo lava flow | 28.39293 | –107.76230 | M3 | T3,T4 | | | |
| 112 | S-5 | Kempter | Tv3 | Agueachic lava flow | 28.23048 | –107.76040 | | | bi,pl | | |
| 113 | S-6 | Kempter | Tv3 | Agueachic lava flow | 28.22792 | –107.75460 | M1,M2 | T2 | bi | S | |
| 114 | N55 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.31915 | –107.73321 | M1 | T1,T5 | | | Pb,Sr,Nd,O |
| 115 | N57 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.32274 | –107.73126 | M1 | T1,T5 | | | |
| 116 | 90-110 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38677 | –107.72996 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 117 | N59 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.32279 | –107.72945 | | | | | |
| 118 | N60 | Wark (PhD) | Tv5 | Rio Verde tuff | 28.32290 | –107.72850 | M1 | T1,T5 | | | Nd,O |

(*continued*)

APPENDIX TABLE 2. SAMPLE INFORMATION (*continued*)

| # | Sample | Collector | Unit | Local unit | Latitude | Longitude | Major elements | Trace elements | K-Ar | Ar-Ar | Isotopes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 119 | S-31 | Kempter | Tv5 | Rio Verde tuff | 28.32079 | –107.72730 | | | san | M | |
| 120 | S-32 | Kempter | Tv6 | Mofo lava flow | 28.24283 | –107.71270 | M1,M2,M3 | T1,T2,T5 | bi,pl | S | Sr,O |
| 121 | N71 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38060 | –107.70577 | M1 | T1,T5 | | | Sr,Nd |
| 122 | S-23 | Kempter | Tv6 | Heredia tuff | 28.20971 | –107.70275 | M2 | T2 | pl | | |
| 123 | 90-112 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38447 | –107.70016 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 124 | 90-115 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38223 | –107.69682 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 125 | S-28 | Kempter | Tv5 | Rio Verde tuff | 28.29995 | –107.69432 | | | pl | | |
| 126 | 90-117 | Wark (PhD) | Tuml | Lagunitas lava flow | 28.38249 | –107.68492 | M3 | T3,T4 | | | Pb,Sr,Nd |
| 127 | C-18 | Swanson | Tv6 | Cascada tuff* | 28.38426 | –107.68341 | | | pl | | Sr |
| 128 | C-13 | Swanson | Tuml? | mafic lava flow | 28.38527 | –107.62738 | M1 | T1 | | | |
| 129 | C-17B | Swanson | Tv5 | Rio Verde tuff | 28.38900 | –107.62424 | M1 | T1 | | | |
| 130 | C-14B | Swanson | Tv4 | Vista tuff | 28.39796 | –107.62350 | M1 | T1 | | | |
| 131 | C-12 | Swanson | Tv5 | Rio Verde tuff | 28.38900 | –107.62210 | | | pl | S | |
| 132 | C-7 | Swanson | Tv4 | Vista tuff | 28.39781 | –107.60949 | | | bi,san | S | |
| 133 | S-25 | Kempter | Tv4 | Vista tuff | 28.40185 | –107.59497 | | | bi,pl | | |
| 134 | S-24 | Kempter | Tv4 | Vista lava flow | 28.23120 | –107.58516 | | | san | | |
| 135 | D77A | Duex | KTi | intrusive | 28.59100 | –107.37078 | M1 | T1 | | | |
| 136 | D86A | Duex | KTi | mafic dike | 28.58307 | –107.36876 | M1 | T1 | | | |
| 137 | D66B | Duex | Tv4 | 10C—mafic flow | 28.61807 | –107.35186 | | | pl | | |
| 138 | D66A | Duex | Tv4 | 10C—felsic flow | 28.61891 | –107.34724 | | | pl | | |
| 139 | D48B | Duex | Tv5 | 30W—felsic tuff | 28.34203 | –107.33251 | | | pl | | |
| 140 | D69C | Duex | Tv5 | 40W—felsic tuff | 28.34445 | –107.33205 | M1 | T1,T2 | pl | | |
| 141 | D48A | Duex | Tv5 | 20W—felsic tuff | 28.34327 | –107.33153 | | | pl | | |
| 142 | D70B | Duex | Tv4 | 10W—felsic tuff | 28.33381 | –107.27709 | M1 | T1 | pl | | |
| 143 | D89B | Duex | Tfr | 50W—felsic flow | 28.30411 | –107.25408 | | | san | S | |
| 144 | D89A | Duex | Tuml | 50W—mafic flow | 28.30161 | –107.25218 | | | wr | | |
| 145 | D84A | Duex | Tv5 | 20W—felsic tuff | 28.27322 | –107.22291 | M1 | T1 | | | |
| 146 | D70D | Duex | Tuml | 50W—mafic flow | 28.36646 | –107.16694 | M1,M2 | T1,T2 | wr | | Pb,Sr,Nd |
| 147 | D73H | Duex | Tv4 | 20C—felsic tuff | 28.53551 | –107.12112 | | | pl | | |
| 148 | D85A | Duex | Tuml | 50C—mafic flow | 28.61760 | –107.03379 | | | pl | | |
| 149 | D76B | Duex | Tfr | 40C—felsic tuff | 28.57548 | –107.03022 | M1 | T1,T2 | san | M | |
| 150 | D76A | Duex | Tuml | 30C—mafic flow | 28.47376 | –107.02100 | M1 | T1 | wr | | Pb,Sr,Nd |
| 151 | D78B | Duex | Tfr | 40C—felsic tuff | 28.38917 | –106.99286 | | | san | S | |
| 152 | D75A | Duex | Tv4 | 10C—felsic flow | 28.27738 | –106.98793 | M1 | T1,T2 | pl | | Pb |
| 153 | D75B | Duex | Tv4 | 10C—felsic flow | 28.27857 | –106.98008 | | | pl | | |
| 154 | D85B | Duex | Tv5 | 40E—intermediate flow? | 28.37064 | –106.85704 | M1 | T1 | | | |
| 155 | J-140 | Stimac | Tfr | Frijol tuff | 28.30445 | –106.84140 | M1,M2 | T1,T2 | san | M | |
| 156 | J-406 | Stimac | Tv1 | Bufa tuffs | 28.22735 | –106.83552 | | | (U-Pb,zr.) | | |
| 157 | D53D | Duex | Tuml | 50E—mafic flow | 28.36608 | –106.83232 | M1 | T1,T2 | wr | | Pb,Sr,Nd |
| 158 | J-212 | Stimac | Tv4 | Yomama tuffs | 28.25176 | –106.83214 | | | san | S,M | |
| 159 | J-256 | Stimac | Tv5 | Caballos tuff | 28.27697 | –106.82658 | M1 | T1 | | | |
| 160 | J-369 | Stimac | Tv5 | Caballos felsic flow | 28.27336 | –106.81440 | M1,M2 | T1,T2 | pl | | Pb |
| 161 | D62A | Duex | Tv5 | 20E—felsic tuff | 28.35807 | –106.80128 | | | pl | | |
| 162 | D62B | Duex | Tv5 | 20E—felsic tuff | 28.35872 | –106.80074 | | | pl | | |
| 163 | J-375 | Stimac | Tv3 | Divisadero felsic flow | 28.24662 | –106.79784 | M1,M2 | T1,T2 | pl | S | |
| 164 | W-300 | Wark (MA) | Tv3 | Loma del Toro int. flows | 28.20848 | –106.79619 | | | pl | | Pb |
| 165 | CUSI | Wark (MA) | Tv3 | Loma del Toro int. flows | 28.21386 | –106.79149 | | | (U-Pb,zr.) | | |
| 166 | W-204 | Wark (MA) | Tuml | mafic dike | 28.19229 | –106.75965 | | | pl | | |
| 167 | W-173 | Wark (MA) | Ti | intrusive porphyry | 28.20786 | –106.72964 | | | bi | | |
| 168 | J-399 | Stimac | Tv6 | Coyachic felsic flow | 28.32892 | –106.71958 | M1 | T1 | | | |
| 169 | WD-8 | Wark (MA) | Tv5 | Durazno tuff | 28.22856 | –106.71516 | | | pl | S | |
| 170 | W-200 | Wark (MA) | Tv5 | Pilares felsic flow | 28.21082 | –106.70998 | M1,M2 | T1,T2 | san | M | Pb |
| 171 | WF-1 | Wark (MA) | Tv5 | Durazno tuff | 28.22540 | –106.70575 | | | san | M | |
| 172 | W-176 | Wark (MA) | Tuml | mafic lava flow | 28.21339 | –106.67615 | M1,M2 | T1,T2 | | | Pb,Sr |
| 173 | I-151 | Ide | Tv4 | Bustillos felsic dome | 28.43351 | –106.65370 | M1 | T1 | | | |
| 174 | I-112 | Ide | Tv4 | Laboricita int. flow | 28.41161 | –106.61423 | M1 | T1 | | | |
| 175 | I-521 | Ide | Tv4 | Buena Vista felsic flow | 28.40184 | –106.61183 | M1,M2 | T1,T2 | san | M | Pb |

(*continued*)

APPENDIX TABLE 2. SAMPLE INFORMATION (*continued*)

| # | Sample | Collector | Unit | Local unit | Latitude | Longitude | Major elements | Trace elements | K-Ar | Ar-Ar | Isotopes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 176 | I-532 | Ide | Tuml | Buena Vista inter. flow | 28.43537 | –106.60757 | M1,M2 | T1,T2 | pl | | Pb |
| 177 | I-44 | Ide | Tv4 | Tambor tuff | 28.41877 | –106.59912 | M1,M2 | T1,T2 | | | |
| 178 | DZ-29 | Conlon | Tv6 | Sta.Rosalia tuffs | 28.03811 | –106.57068 | M1 | T1 | | | |
| 179 | DZ-2 | Conlon | Tv6 | Durazno felsic lavas | 28.05689 | –106.56129 | M1,M2 | T2 | | | |
| 180 | I-470 | Ide | Tv4 | Abajo tuff | 28.38927 | –106.55711 | | | san | M | |
| 181 | I-133 | Ide | Tuml | Ojo Blanco mafic flow | 28.46158 | –106.54904 | M1,M2 | T1,T2 | | | Pb,Sr,Nd |
| 182 | DZ-31 | Conlon | Tv6 | Durazno felsic lavas | 28.09154 | –106.53578 | | | san | M | Pb |
| 183 | I-494 | Ide | Tv4 | Flores tuff | 28.40989 | –106.53069 | | | bi,pl | | |
| 184 | I-478 | Ide | Tv4 | Alamo tuff | 28.40111 | –106.52248 | M1 | T1 | san | M | |
| 185 | I-164 | Ide | Tv4 | Tambor tuff | 28.44569 | –106.51908 | M1 | | san | M | |
| 186 | HF-1 | Ide | Tuml | trachyte flow | 28.38635 | –106.49677 | M1 | T1 | pl | | |
| 187 | VG-7B | Conlon | Tv4 | Vicente Guerrero tuffs | 28.13274 | –106.48129 | M1,M2 | T2 | san | M | |
| 188 | CM634 | R.Mauger | Tv4? | Tambor tuff? | 28.54110 | –106.46527 | | | san | M | |
| 189 | CM449 | R.Mauger | Tuml | mafic lava flow | 28.47909 | –106.45849 | | | wr | | |
| 190 | PLM | Ide | Tuml | Trias intermed. Flow | 28.33775 | –106.43381 | M1,M2 | T1,T2 | pl | | Pb |
| 191 | HW-1 | Conlon | Tuml | Sta. Rosa mafic flows | 28.31771 | –106.41046 | M1 | T1 | | | |
| 192 | Ni-102 | Conlon | Tv6 | Sta. Rosalia tuff | 28.07628 | –106.40754 | M1,M2 | T1,T2 | | | |
| 193 | J-CH | Conlon | Tv4 | Jacales tuff | 28.27343 | –106.40144 | M1 | T1 | | | |
| 194 | PC-1 | Conlon | Tuml | Sta. Rosa mafic flows | 28.29311 | –106.39039 | M1,M2 | T1,T2 | wr | | Pb,Sr |
| 195 | Ni-30 | Conlon | Tv6 | Sta. Rosalia tuffs | 28.10329 | –106.38735 | M1 | T1 | pl | | |
| 196 | Bvtbl | Cook | Tv1 | Sepulveda flows | 28.45945 | –106.38120 | | | pl | | |
| 197 | PER | Cook | Tv1 | Perales flow | 28.40145 | –106.36257 | | | pl | | Pb |
| 198 | J-ER | Conlon | Tv4 | Jacales tuff | 28.33023 | –106.34095 | | | san | M | |
| 199 | ER-51 | Conlon | Tv4 | Jacales tuff | 28.32277 | –106.33677 | M1 | T1 | | | |
| 200 | ER-13B | Conlon | Tv4 | Jacales tuff | 28.32313 | –106.33599 | M1 | | | | |
| 201 | CG-BL | Conlon | Tv2 | Cerro Grande tuff | 28.22754 | –106.33255 | M1 | T1 | san | M | |
| 202 | NJ-5 | Conlon | Tv4 | Jacales tuff | 28.33414 | –106.32245 | M1,M2 | T1,T2 | | | |
| 203 | Monz | Conlon | KTi | Magistral intrusive | 28.14909 | –106.31778 | M1 | T1 | | | |
| 204 | CH88-16 | McDowell | KTi | Magistral intrusive | 28.15143 | –106.31476 | | | hbl, (U-Pb,zr.) | | |
| 205 | Z-VIT | Conlon | Tv4 | Los Fierros tuff | 28.23577 | –106.30933 | M1 | T1 | | | |
| 206 | CH88-13 | Cook | Tv1 | Chivato tuff | 28.46838 | –106.30078 | | | (U-Pb,zr.) | | |
| 207 | RED | Cook | Tv1 | Canada de Gato flows | 28.42484 | –106.29098 | M1,M2 | T2 | bi,san | M | |
| 208 | RP | Conlon | Tv4 | Rancho de Pena tuff | 28.33623 | –106.27246 | M1 | T1 | san | M | |
| 209 | SC11-9 | Cook | Tv4 | Palomas tuff | 28.39311 | –106.26480 | | | san | M | |
| 210 | SC11-10 | Cook | Tv4 | Palomas tuff | 28.38399 | –106.26425 | | | san | M | |
| 211 | EC1 | Megaw | Tv4 | Charco tuff | 28.41730 | –106.15376 | M1 | T1,T2 | san | M | |
| 212 | ECD | Megaw | Tuml | San Ramon mafic flows | 28.42299 | –106.15086 | M1 | T1 | wr | | Pb,Sr,Nd |
| 213 | 4RSRB | Megaw | Tuml | San Ramon mafic flows | 28.56567 | –106.13313 | M1,M2 | T1 | | | Pb,Sr,Nd |
| 214 | RND1 | Megaw | Tv4 | Soto unit | 28.19081 | –106.07370 | M1 | T1,T2 | san | | Pb |
| 215 | TTV | Megaw | Tv4 | Toro rhyolite | 28.44347 | –106.03549 | M1 | T1,T2 | bi,san | M | |
| 216 | TTD | Megaw | Tv4 | Toro rhyolite | 28.47746 | –106.02566 | | | san | | |
| 217 | 4EN1 | Megaw | Tv4 | Soto unit | 28.23555 | –105.99134 | M1 | T1 | san | S | |
| 218 | 4MPB | Megaw | Tuml | San Ramon mafic flows | 28.51325 | –105.97291 | M1 | T1 | wr | | |
| 219 | PMES1 | Megaw | Tv4 | East Side unit | 28.48116 | –105.94576 | M1 | T1 | | | |
| 220 | CLLD | Megaw | Tv4 | Sta. Eulalia tuff | 28.54469 | –105.93821 | M1 | T1,T2 | pl | S | |
| 221 | OWLD | Megaw | Tv4 | Carretas tuff | 28.33163 | –105.90426 | M1 | T1,T2 | san | S | |
| 222 | 4BAS1 | Megaw | Tuml | San Ramon mafic flows | 28.37868 | –105.88217 | M1 | T1 | | | |
| 223 | XYZB | Megaw | Tuml | San Ramon mafic flows | 28.31917 | –105.85082 | M1 | T1 | wr | | |

*Note*: Original stratigraphic nomenclature revised in Wark et al. (1990). Major elements: M1—analyses at University of Texas, Austin, using standard wet chemical techiniques; M2—analyses at Washington State University Geoanalytical Lab by X-ray fluorescence; M3—analyses at University of Massachusetts, Amherst by X-ray fluorescence. Trace elements: T1—analyses at University of Texas, Austin, by XRF (Rb, Sr, Y, Zr, Nb only); T2—analyses at Washington State University Geoanalytical Lab by X-ray Fluorescence and/or ICP-MS; T3—analyses at University of Massachusetts, Amherst, by X-ray fluorescence; T4—analyses at Oregon State University by Neutron Activation; T5—analyses at Los Alamos National Laboratory by Neutron Activation. K-Ar dating (all analyses at University of Texas, Austin): san—sanidine-anorthoclase; bi—biotite; pl—plagioclase; hbl—hornblende; wr—whole rock. Includes four U-Pb ages for zircon. Ar-Ar dating (all analyses at New Mexico Geochronology Lab by laser fusion): S—single grain data; M—multigrain data. Isotopic analyses: *—analyzed at the University of Colorado; all others at University of Texas, Austin.

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ± 1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#11 11-15-1,** Sanidine, J = 0.0007398 ± 0.05%, D = 1.003 ± 0.001, NM-192A, Lab# = 55917 | | | | | | | | |
| | 10 | 25.42 | 0.0072 | 1.538 | 3.660 | 70.9 | 98.2 | 33.02 | 0.10 |
| | 04 | 25.30 | 0.0072 | 0.9731 | 3.634 | 70.4 | 98.9 | 33.07 | 0.10 |
| | 11 | 25.23 | 0.0072 | 0.5071 | 3.063 | 71.0 | 99.4 | 33.17 | 0.12 |
| | 01 | 25.32 | 0.0071 | 0.5898 | 5.616 | 72.4 | 99.3 | 33.246 | 0.064 |
| | 02 | 25.46 | 0.0060 | 1.075 | 3.117 | 85.4 | 98.8 | 33.25 | 0.12 |
| | 15 | 25.29 | 0.0065 | 0.4188 | 2.916 | 78.9 | 99.5 | 33.28 | 0.11 |
| | 06 | 25.64 | 0.0066 | 1.584 | 5.010 | 77.8 | 98.2 | 33.284 | 0.077 |
| | 05 | 25.88 | 0.0066 | 2.370 | 6.294 | 77.7 | 97.3 | 33.292 | 0.062 |
| | 07 | 25.51 | 0.0062 | 1.084 | 3.896 | 82.8 | 98.7 | 33.307 | 0.094 |
| | 03 | 25.71 | 0.0068 | 1.699 | 6.713 | 75.1 | 98.0 | 33.338 | 0.058 |
| | 09 | 25.56 | 0.0072 | 1.099 | 6.605 | 71.1 | 98.7 | 33.373 | 0.062 |
| | 13 | 25.41 | 0.0066 | 0.5007 | 11.883 | 77.8 | 99.4 | 33.408 | 0.050 |
| | 14 | 26.16 | 0.0067 | 2.973 | 5.982 | 76.3 | 96.6 | 33.437 | 0.071 |
| | 12 | 25.50 | 0.0062 | 0.5211 | 9.534 | 82.6 | 99.4 | 33.511 | 0.053 |
| | **Mean age ± 2σ** | | n = 14 | MSWD = 2.86 | | 76.4 ± 9.8 | | **33.335** | **0.073** |
| | **#17 3-25-4,** Sanidine, J = 0.00074 ± 0.05%, D = 1.003 ± 0.001, NM-192A, Lab# = 55919 | | | | | | | | |
| # | *02* | *83.07* | *0.8322* | *213.6* | *0.801* | *0.61* | *24.1* | *26.55* | *0.80* |
| | 04 | 49.85 | 0.4789 | 99.36 | 1.215 | 1.1 | 41.2 | 27.21 | 0.44 |
| | 11 | 34.80 | 0.5739 | 48.02 | 1.136 | 0.89 | 59.4 | 27.38 | 0.30 |
| | 14 | 47.07 | 0.5244 | 89.33 | 1.146 | 0.97 | 44.0 | 27.46 | 0.45 |
| | 12 | 52.70 | 0.5405 | 107.8 | 1.527 | 0.94 | 39.6 | 27.67 | 0.41 |
| | 07 | 48.02 | 0.2656 | 91.23 | 3.178 | 1.9 | 43.9 | 27.93 | 0.26 |
| | 08 | 27.56 | 0.1391 | 20.95 | 3.704 | 3.7 | 77.6 | 28.32 | 0.14 |
| | 13 | 42.94 | 0.1591 | 73.01 | 2.852 | 3.2 | 49.8 | 28.32 | 0.25 |
| | 05 | 97.47 | 0.2867 | 255.9 | 3.296 | 1.8 | 22.4 | 28.97 | 0.52 |
| # | *17* | *28.41* | *2.995* | *22.46* | *0.206* | *0.17* | *77.5* | *29.2* | *1.2* |
| # | *10* | *33.04* | *1.581* | *37.45* | *0.325* | *0.32* | *66.9* | *29.31* | *0.79* |
| | **Mean age ± 2σ** | | n = 8 | MSWD = 2.79 | | 1.8 ± 2.2 | | **28.09** | **0.31** |
| | **#18 10-20-1,** Sanidine, J = 0.0007404 ± 0.05%, D = 1.003 ± 0.001, NM-192A, Lab# = 55918 | | | | | | | | |
| # | *07* | *45.79* | *0.0079* | *70.27* | *5.065* | *64.4* | *54.7* | *33.13* | *0.20* |
| | 05 | 26.45 | 0.0065 | 4.614 | 4.088 | 78.2 | 94.8 | 33.200 | 0.091 |
| | 10 | 27.99 | 0.0077 | 9.815 | 5.787 | 66.6 | 89.6 | 33.212 | 0.085 |
| | 06 | 25.54 | 0.0068 | 1.322 | 3.775 | 74.8 | 98.5 | 33.279 | 0.099 |
| | 04 | 25.54 | 0.0087 | 1.296 | 4.363 | 58.7 | 98.5 | 33.29 | 0.11 |
| | 08 | 26.17 | 0.0079 | 3.440 | 4.333 | 64.9 | 96.1 | 33.290 | 0.084 |
| | 13 | 25.35 | 0.0062 | 0.4609 | 3.386 | 81.7 | 99.5 | 33.37 | 0.10 |
| | 03 | 25.42 | 0.0069 | 0.6130 | 7.350 | 73.5 | 99.3 | 33.402 | 0.058 |
| | 14 | 25.34 | 0.0075 | 0.2959 | 6.174 | 68.2 | 99.7 | 33.415 | 0.065 |
| | 12 | 25.36 | 0.0062 | 0.3734 | 7.240 | 82.6 | 99.6 | 33.416 | 0.061 |
| | 11 | 25.71 | 0.0076 | 1.465 | 9.255 | 66.8 | 98.3 | 33.454 | 0.055 |
| | 02 | 25.46 | 0.0092 | 0.5963 | 11.906 | 55.3 | 99.3 | 33.466 | 0.050 |
| | 01 | 25.38 | 0.0059 | 0.2284 | 10.339 | 86.3 | 99.7 | 33.497 | 0.055 |
| | 09 | 25.98 | 0.0068 | 2.216 | 10.949 | 74.7 | 97.5 | 33.514 | 0.055 |
| | 15 | 25.69 | 0.0072 | 1.146 | 7.195 | 71.4 | 98.7 | 33.554 | 0.063 |
| | **Mean age ± 2σ** | | n = 14 | MSWD = 2.22 | | 71.7 ± 17.9 | | **33.422** | **0.063** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ± 1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#57 S-27,** Sanidine, J = 0.0007462 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55947 | | | | | | | | |
| *#* | *11* | *25.00* | *0.0060* | *0.4021* | *5.755* | *85.6* | *99.5* | *33.182* | *0.065* |
| *#* | *03* | *25.00* | *0.0070* | *0.4004* | *6.131* | *73.4* | *99.5* | *33.182* | *0.061* |
| | 01 | 25.15 | 0.0066 | 0.5719 | 2.536 | 76.9 | 99.3 | 33.31 | 0.11 |
| | 06 | 25.13 | 0.0072 | 0.4851 | 5.502 | 70.6 | 99.4 | 33.333 | 0.068 |
| | 12 | 25.19 | 0.0065 | 0.6160 | 9.939 | 78.5 | 99.3 | 33.356 | 0.053 |
| | 14 | 25.13 | 0.0052 | 0.3829 | 6.672 | 97.2 | 99.6 | 33.363 | 0.065 |
| | 09 | 25.15 | 0.0065 | 0.4471 | 6.337 | 78.5 | 99.5 | 33.368 | 0.060 |
| | 15 | 25.11 | 0.0071 | 0.2644 | 4.641 | 72.0 | 99.7 | 33.389 | 0.071 |
| | 10 | 25.14 | 0.0070 | 0.3094 | 8.688 | 72.6 | 99.6 | 33.403 | 0.055 |
| | 07 | 25.09 | 0.0071 | 0.1384 | 8.015 | 71.9 | 99.8 | 33.405 | 0.054 |
| | 05 | 25.25 | 0.0068 | 0.6440 | 8.780 | 75.3 | 99.2 | 33.426 | 0.057 |
| | 02 | 25.16 | 0.0067 | 0.2556 | 6.333 | 76.2 | 99.7 | 33.453 | 0.065 |
| | 13 | 25.26 | 0.0066 | 0.6068 | 12.399 | 77.0 | 99.3 | 33.454 | 0.050 |
| | 08 | 25.33 | 0.0067 | 0.7586 | 12.126 | 76.1 | 99.1 | 33.478 | 0.056 |
| | 04 | 25.22 | 0.0069 | 0.3911 | 12.455 | 73.7 | 99.5 | 33.482 | 0.051 |
| | **Mean age ± 2σ** | | n = 13 | MSWD = 0.74 | | 76.6 ± 13.4 | | **33.412** | **0.044** |
| | **#58 S-14,** Sanidine, J = 0.0007421 ± 0.06%, D = 1.003 ± 0.001, NM-192C, Lab# = 55931 | | | | | | | | |
| | 19 | 23.41 | 0.0337 | 7.109 | 2.359 | 15.1 | 91.0 | 28.31 | 0.16 |
| | 16 | 21.74 | 0.0249 | 1.167 | 2.800 | 20.5 | 98.4 | 28.42 | 0.12 |
| | 25 | 21.72 | 0.0654 | 1.071 | 2.145 | 7.8 | 98.6 | 28.43 | 0.15 |
| | 24 | 21.50 | 0.0231 | 0.1820 | 2.646 | 22.1 | 99.8 | 28.49 | 0.13 |
| | 18 | 25.35 | 0.0556 | 13.14 | 2.325 | 9.2 | 84.7 | 28.52 | 0.21 |
| | 08 | 21.77 | 0.0275 | 0.9131 | 4.143 | 18.5 | 98.8 | 28.560 | 0.076 |
| | 22 | 22.05 | 0.0279 | 1.841 | 2.400 | 18.3 | 97.5 | 28.57 | 0.16 |
| | 10 | 21.62 | 0.0209 | 0.3190 | 4.426 | 24.4 | 99.6 | 28.592 | 0.072 |
| | 03 | 22.24 | 0.0676 | 2.327 | 4.292 | 7.5 | 96.9 | 28.630 | 0.079 |
| | 20 | 26.58 | 0.0593 | 16.93 | 3.866 | 8.6 | 81.2 | 28.67 | 0.12 |
| | 12 | 21.82 | 0.0299 | 0.7950 | 2.316 | 17.1 | 98.9 | 28.67 | 0.11 |
| | 26 | 22.80 | 0.0177 | 3.985 | 5.831 | 28.8 | 94.8 | 28.717 | 0.077 |
| | 09 | 22.19 | 0.0153 | 1.925 | 3.443 | 33.5 | 97.4 | 28.717 | 0.091 |
| | 07 | 21.74 | 0.0378 | 0.3747 | 6.215 | 13.5 | 99.5 | 28.727 | 0.061 |
| | 04 | 31.28 | 0.0280 | 32.58 | 4.522 | 18.2 | 69.2 | 28.75 | 0.14 |
| | 14 | 23.70 | 0.0484 | 6.890 | 3.528 | 10.5 | 91.4 | 28.772 | 0.098 |
| | 23 | 22.83 | 0.0253 | 3.923 | 3.503 | 20.1 | 94.9 | 28.783 | 0.087 |
| | 13 | 23.80 | 0.0456 | 7.113 | 5.575 | 11.2 | 91.2 | 28.827 | 0.077 |
| | 17 | 26.66 | 0.0315 | 16.77 | 7.310 | 16.2 | 81.4 | 28.83 | 0.15 |
| | 01 | 25.95 | 0.0245 | 14.34 | 13.929 | 20.8 | 83.7 | 28.834 | 0.065 |
| | 05 | 25.20 | 0.0187 | 11.75 | 3.708 | 27.2 | 86.2 | 28.86 | 0.11 |
| | 15 | 22.57 | 0.0179 | 2.801 | 3.783 | 28.5 | 96.3 | 28.873 | 0.086 |
| | 11 | 21.95 | 0.0621 | 0.6044 | 2.066 | 8.2 | 99.2 | 28.92 | 0.13 |
| | 21 | 22.37 | 0.0164 | 1.883 | 3.356 | 31.1 | 97.5 | 28.971 | 0.093 |
| | 02 | 24.08 | 0.0568 | 7.686 | 4.429 | 9.0 | 90.6 | 28.972 | 0.088 |
| | 06 | 21.89 | 0.0576 | 0.2127 | 2.670 | 8.9 | 99.7 | 28.99 | 0.10 |
| | **Mean age ± 2σ** | | n = 26 | MSWD = 2.60 | | 17.5 ± 15.8 | | **28.737** | **0.069** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ± 1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#66 N-09,** Sanidine, J=0.0007437±0.05%, D=1.003±0.001, NM-192C, Lab#=55930 | | | | | | | | |
| # | *30* | *21.55* | *0.0375* | *1.067* | *2.648* | *13.6* | *98.6* | *28.27* | *0.15* |
| | 29 | 21.59 | 0.0499 | 0.6447 | 3.229 | 10.2 | 99.1 | 28.487 | 0.095 |
| | 05 | 21.68 | 0.0446 | 0.9084 | 2.798 | 11.4 | 98.8 | 28.51 | 0.10 |
| | 12 | 21.78 | 0.0364 | 1.229 | 4.520 | 14.0 | 98.3 | 28.518 | 0.074 |
| | 14 | 22.17 | 0.0547 | 2.426 | 3.219 | 9.3 | 96.8 | 28.558 | 0.099 |
| | 10 | 21.73 | 0.0497 | 0.9283 | 2.508 | 10.3 | 98.8 | 28.56 | 0.11 |
| | 22 | 21.81 | 0.0513 | 1.183 | 4.168 | 9.9 | 98.4 | 28.567 | 0.072 |
| | 13 | 22.46 | 0.0452 | 3.175 | 5.697 | 11.3 | 95.8 | 28.647 | 0.066 |
| | 06 | 21.67 | 0.0340 | 0.4491 | 4.348 | 15.0 | 99.4 | 28.668 | 0.072 |
| | 18 | 21.86 | 0.0360 | 1.101 | 5.924 | 14.2 | 98.5 | 28.669 | 0.065 |
| | 25 | 21.82 | 0.0392 | 0.8870 | 3.746 | 13.0 | 98.8 | 28.694 | 0.078 |
| | 01 | 22.16 | 0.0444 | 2.007 | 4.347 | 11.5 | 97.3 | 28.707 | 0.077 |
| | 04 | 21.70 | 0.0448 | 0.4642 | 2.275 | 11.4 | 99.4 | 28.71 | 0.13 |
| | 11 | 22.10 | 0.0699 | 1.790 | 5.247 | 7.3 | 97.6 | 28.716 | 0.069 |
| | 02 | 21.70 | 0.0304 | 0.4140 | 5.320 | 16.8 | 99.4 | 28.723 | 0.063 |
| | 09 | 21.91 | 0.0354 | 1.121 | 5.255 | 14.4 | 98.5 | 28.730 | 0.070 |
| | 07 | 21.76 | 0.0430 | 0.6065 | 3.430 | 11.9 | 99.2 | 28.733 | 0.095 |
| | 19 | 21.89 | 0.0423 | 1.010 | 7.546 | 12.1 | 98.7 | 28.740 | 0.097 |
| | 26 | 21.87 | 0.0510 | 0.9076 | 4.579 | 10.0 | 98.8 | 28.758 | 0.066 |
| | 03 | 21.91 | 0.0464 | 1.023 | 4.071 | 11.0 | 98.6 | 28.767 | 0.077 |
| | 08 | 21.75 | 0.0501 | 0.4822 | 4.618 | 10.2 | 99.4 | 28.770 | 0.074 |
| | 24 | 22.05 | 0.0450 | 1.445 | 11.193 | 11.3 | 98.1 | 28.780 | 0.076 |
| | 17 | 22.97 | 0.0430 | 4.568 | 16.949 | 11.9 | 94.1 | 28.781 | 0.081 |
| | 23 | 22.30 | 0.0493 | 2.303 | 4.472 | 10.4 | 97.0 | 28.786 | 0.073 |
| | 27 | 22.07 | 0.0440 | 1.490 | 5.327 | 11.6 | 98.0 | 28.798 | 0.074 |
| | 21 | 22.05 | 0.0407 | 1.415 | 7.168 | 12.5 | 98.1 | 28.801 | 0.059 |
| | 15 | 22.49 | 0.0491 | 2.750 | 7.184 | 10.4 | 96.4 | 28.854 | 0.058 |
| | 16 | 22.25 | 0.0500 | 1.866 | 8.507 | 10.2 | 97.5 | 28.89 | 0.12 |
| | 20 | 22.33 | 0.0464 | 2.003 | 5.621 | 11.0 | 97.4 | 28.943 | 0.086 |
| | 28 | 22.08 | 0.0469 | 1.010 | 4.294 | 10.9 | 98.7 | 28.989 | 0.069 |
| | **Mean age ± 2σ** | | n=29 | MSWD=2.30 | | 11.6 ±3.8 | | **28.730** | **0.052** |
| | **#67 S-22,** Sanidine, J=0.000746±0.05%, D=1.003±0.001, NM-192D, Lab#=55949 | | | | | | | | |
| # | *13* | *105.1* | *-0.0627* | *276.9* | *0.033* | *-* | *22.1* | *31.0* | *7.0* |
| # | *08* | *34.85* | *0.0092* | *22.06* | *4.475* | *55.3* | *81.3* | *37.73* | *0.13* |
| # | *12* | *52.17* | *0.0092* | *79.41* | *1.656* | *55.7* | *55.0* | *38.22* | *0.32* |
| # | *14* | *36.16* | *0.0090* | *24.47* | *1.726* | *56.7* | *80.0* | *38.52* | *0.23* |
| | 01 | 35.75 | 0.0156 | 22.14 | 4.721 | 32.7 | 81.7 | 38.89 | 0.12 |
| | 15 | 29.77 | 0.0089 | 1.738 | 2.321 | 57.6 | 98.3 | 38.95 | 0.14 |
| | 10 | 29.57 | 0.0102 | 0.5732 | 2.756 | 50.0 | 99.4 | 39.14 | 0.12 |
| | 03 | 31.83 | 0.0177 | 8.187 | 2.246 | 28.8 | 92.4 | 39.15 | 0.15 |
| | 09 | 29.65 | 0.0098 | 0.8197 | 2.216 | 52.1 | 99.2 | 39.16 | 0.13 |
| | 05 | 29.89 | 0.0097 | 1.588 | 6.892 | 52.6 | 98.4 | 39.165 | 0.067 |
| | 11 | 29.85 | 0.0122 | 1.265 | 2.351 | 41.9 | 98.8 | 39.24 | 0.14 |
| | 07 | 30.38 | 0.0100 | 2.789 | 8.370 | 50.9 | 97.3 | 39.351 | 0.067 |
| | 02 | 30.06 | 0.0096 | 1.535 | 4.277 | 53.3 | 98.5 | 39.412 | 0.092 |
| | 06 | 29.94 | 0.0092 | 0.9862 | 3.049 | 55.2 | 99.0 | 39.47 | 0.11 |
| # | *04* | *35.29* | *1.884* | *19.47* | *0.222* | *0.27* | *84.1* | *39.6* | *1.1* |
| | **Mean age ± 2σ** | | n=10 | MSWD=2.88 | | 47.5 ±19.6 | | **39.23** | **0.11** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}$Ar/$^{39}$Ar | $^{37}$Ar/$^{39}$Ar | $^{36}$Ar/$^{39}$Ar ($\times 10^{-3}$) | $^{39}$Ar$_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}$Ar* (%) | Age (Ma) | ± 1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#109 S-4,** Sanidine, J = 0.0007404 ± 0.05%, D = 1.003 ± 0.001, NM-192C, Lab# = 55934 | | | | | | | | |
| # | 19 | 24.75 | 0.1768 | 4.652 | 0.273 | 2.9 | 94.5 | 30.98 | 0.70 |
| # | 40 | 24.22 | 0.1302 | 1.899 | 0.145 | 3.9 | 97.7 | 31.3 | 1.3 |
| # | 34 | 24.59 | 0.1842 | 3.149 | 0.270 | 2.8 | 96.3 | 31.35 | 0.71 |
| # | 12 | 24.72 | 0.3146 | 3.266 | 0.439 | 1.6 | 96.2 | 31.50 | 0.52 |
| # | 15 | 24.24 | 0.1980 | 1.397 | 0.237 | 2.6 | 98.4 | 31.57 | 0.94 |
| # | 49 | 25.39 | 0.1129 | 5.185 | 0.084 | 4.5 | 94.0 | 31.6 | 2.1 |
| # | 30 | 24.33 | 0.1968 | 1.541 | 0.910 | 2.6 | 98.2 | 31.64 | 0.24 |
| # | 39 | 24.44 | 0.1329 | 1.812 | 0.126 | 3.8 | 97.9 | 31.7 | 1.4 |
| # | 33 | 24.77 | 0.1878 | 2.902 | 0.331 | 2.7 | 96.6 | 31.68 | 0.58 |
| # | 21 | 24.81 | 0.1808 | 3.005 | 0.676 | 2.8 | 96.5 | 31.70 | 0.31 |
| # | 28 | 24.13 | 0.1784 | 0.6160 | 0.198 | 2.9 | 99.3 | 31.73 | 0.94 |
| | 01 | 24.28 | 0.1801 | 0.9154 | 2.214 | 2.8 | 98.9 | 31.81 | 0.12 |
| # | 11 | 24.51 | 0.1667 | 1.591 | 0.499 | 3.1 | 98.1 | 31.85 | 0.47 |
| # | 36 | 24.62 | 0.1740 | 1.863 | 0.341 | 2.9 | 97.8 | 31.88 | 0.53 |
| | 20 | 24.38 | 0.1828 | 1.007 | 1.452 | 2.8 | 98.8 | 31.91 | 0.14 |
| # | 04 | 24.30 | 0.1978 | 0.6172 | 0.566 | 2.6 | 99.3 | 31.96 | 0.41 |
| # | 51 | 24.63 | 0.1828 | 1.685 | 0.158 | 2.8 | 98.0 | 32.0 | 1.1 |
| # | 46 | 24.74 | 0.1521 | 1.988 | 0.177 | 3.4 | 97.7 | 32.0 | 1.0 |
| | 02 | 24.47 | 0.0080 | 0.6648 | 2.869 | 63.5 | 99.2 | 32.13 | 0.11 |
| | 08 | 24.35 | 0.0057 | 0.2531 | 1.691 | 89.3 | 99.7 | 32.14 | 0.15 |
| # | 17 | 30.46 | 0.1749 | 20.98 | 0.254 | 2.9 | 79.7 | 32.15 | 0.86 |
| | 10 | 24.47 | 0.0197 | 0.5254 | 0.969 | 25.9 | 99.4 | 32.19 | 0.25 |
| | 47 | 24.55 | 0.0105 | 0.7260 | 0.332 | 48.7 | 99.1 | 32.22 | 0.56 |
| # | 27 | 24.74 | 0.1763 | 1.399 | 0.287 | 2.9 | 98.4 | 32.22 | 0.67 |
| # | 32 | 24.41 | 0.2083 | 0.2894 | 0.204 | 2.4 | 99.7 | 32.22 | 0.91 |
| # | 38 | 24.45 | 0.1719 | 0.3128 | 0.220 | 3.0 | 99.7 | 32.27 | 0.83 |
| # | 41 | 24.58 | 0.1620 | 0.6947 | 0.367 | 3.1 | 99.2 | 32.29 | 0.51 |
| # | 03 | 24.53 | 0.1697 | 0.3612 | 0.476 | 3.0 | 99.6 | 32.35 | 0.47 |
| | 35 | 24.38 | 0.0269 | –0.2009 | 0.305 | 19.0 | 100.3 | 32.35 | 0.63 |
| # | 07 | 24.11 | 1.462 | –0.7383 | 0.133 | 0.35 | 101.4 | 32.4 | 1.6 |
| # | 26 | 24.65 | 0.2048 | 0.5874 | 0.431 | 2.5 | 99.4 | 32.43 | 0.46 |
| # | 05 | 25.48 | 0.1973 | 3.338 | 0.569 | 2.6 | 96.2 | 32.45 | 0.43 |
| # | 09 | 25.34 | 0.1881 | 2.849 | 0.437 | 2.7 | 96.7 | 32.45 | 0.54 |
| # | 13 | 24.49 | 0.1854 | –0.1462 | 0.314 | 2.8 | 100.2 | 32.50 | 0.71 |
| # | 29 | 24.91 | 0.2343 | 1.155 | 0.579 | 2.2 | 98.7 | 32.55 | 0.35 |
| # | 31 | 24.85 | 0.1679 | 0.8981 | 0.255 | 3.0 | 99.0 | 32.56 | 0.78 |
| # | 43 | 24.86 | 0.0936 | 0.8055 | 0.149 | 5.4 | 99.1 | 32.6 | 1.2 |
| # | 18 | 24.19 | 0.1607 | –1.5621 | 0.189 | 3.2 | 102.0 | 32.65 | 0.98 |
| # | 37 | 24.61 | 0.1448 | –0.3423 | 0.251 | 3.5 | 100.5 | 32.72 | 0.73 |
| # | 48 | 24.75 | 0.1815 | 0.1407 | 0.199 | 2.8 | 99.9 | 32.73 | 0.94 |
| # | 42 | 24.86 | 0.0690 | 0.3841 | 0.104 | 7.4 | 99.6 | 32.8 | 1.8 |
| # | 23 | 25.40 | 0.1638 | 2.135 | 0.364 | 3.1 | 97.6 | 32.80 | 0.56 |
| # | 06 | 24.75 | 0.1685 | –0.4300 | 0.142 | 3.0 | 100.6 | 33.0 | 1.6 |
| # | 22 | 24.87 | 0.1957 | –0.2531 | 0.224 | 2.6 | 100.4 | 33.04 | 0.85 |
| # | 25 | 24.53 | 0.1783 | –2.0466 | 0.319 | 2.9 | 102.5 | 33.29 | 0.62 |
| # | 50 | 25.08 | 0.8474 | –0.0992 | 0.119 | 0.60 | 100.4 | 33.3 | 1.5 |
| # | 45 | 25.10 | 0.1476 | –0.4676 | 0.246 | 3.5 | 100.6 | 33.42 | 0.72 |
| # | 14 | 24.36 | 0.1667 | –3.5364 | 0.148 | 3.1 | 104.3 | 33.6 | 1.5 |
| # | 16 | 25.84 | 0.2148 | 0.8417 | 0.151 | 2.4 | 99.1 | 33.9 | 1.2 |
| # | 44 | 25.17 | 0.1275 | –3.2662 | 0.124 | 4.0 | 103.9 | 34.6 | 1.5 |
| # | 24 | 24.86 | 0.9081 | –7.1420 | 0.077 | 0.56 | 108.8 | 35.8 | 2.4 |
| | **Mean age ± 2σ** | | n = 7 | MSWD = 1.06 | | 36.0 ±65.1 | | **32.01** | **0.13** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#113 S-6,** Sanidine, J = 0.0007466 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55948 | | | | | | | | |
| # | 25 | 72.66 | 4.298 | 167.1 | 0.272 | 0.12 | 32.5 | 31.7 | 1.1 |
| # | 10 | 53.01 | 3.507 | 99.45 | 0.690 | 0.15 | 45.1 | 32.00 | 0.54 |
| # | 20 | 50.01 | 4.927 | 88.46 | 0.445 | 0.10 | 48.5 | 32.52 | 0.65 |
| # | 04 | 42.45 | 2.676 | 60.77 | 0.298 | 0.19 | 58.2 | 33.05 | 0.92 |
| # | 16 | 50.02 | 3.096 | 85.75 | 0.882 | 0.16 | 49.9 | 33.36 | 0.50 |
| # | 24 | 39.26 | 2.571 | 49.02 | 0.890 | 0.20 | 63.6 | 33.40 | 0.37 |
| # | 01 | 67.27 | 3.298 | 143.3 | 0.832 | 0.15 | 37.5 | 33.70 | 0.60 |
| # | 11 | 35.81 | 4.261 | 36.65 | 0.479 | 0.12 | 70.7 | 33.90 | 0.58 |
| # | 26 | 43.68 | 1.688 | 62.24 | 0.545 | 0.30 | 58.2 | 33.97 | 0.53 |
| # | 28 | 34.37 | 2.868 | 30.64 | 0.526 | 0.18 | 74.3 | 34.16 | 0.47 |
| # | 29 | 42.98 | 3.418 | 59.44 | 0.115 | 0.15 | 59.8 | 34.4 | 1.8 |
| # | 14 | 27.13 | 2.580 | 5.431 | 0.341 | 0.20 | 94.9 | 34.41 | 0.69 |
| # | 23 | 38.22 | 1.813 | 42.59 | 0.624 | 0.28 | 67.5 | 34.44 | 0.43 |
| # | 02 | 36.59 | 2.358 | 37.01 | 0.766 | 0.22 | 70.6 | 34.54 | 0.39 |
| # | 03 | 46.56 | 2.282 | 70.16 | 0.944 | 0.22 | 55.9 | 34.76 | 0.42 |
| # | 12 | 34.31 | 1.949 | 28.42 | 0.449 | 0.26 | 76.0 | 34.83 | 0.56 |
| # | 09 | 31.00 | 2.401 | 17.14 | 0.935 | 0.21 | 84.3 | 34.92 | 0.29 |
| | 18 | 27.71 | 0.0104 | 5.172 | 3.025 | 49.0 | 94.5 | 34.92 | 0.13 |
| # | 05 | 26.73 | 2.008 | 2.544 | 0.702 | 0.25 | 97.8 | 34.93 | 0.36 |
| | 17 | 27.77 | 0.0142 | 5.299 | 10.860 | 35.9 | 94.4 | 34.962 | 0.064 |
| # | 15 | 33.58 | 2.316 | 25.71 | 0.713 | 0.22 | 77.9 | 34.97 | 0.40 |
| | 19 | 26.52 | 0.0108 | 1.009 | 3.331 | 47.1 | 98.9 | 34.98 | 0.11 |
| | 21 | 27.06 | 0.0122 | 2.832 | 3.801 | 41.8 | 96.9 | 34.978 | 0.099 |
| | 30 | 26.82 | 0.0115 | 1.981 | 5.141 | 44.5 | 97.8 | 34.996 | 0.071 |
| | 22 | 26.88 | 0.0111 | 1.970 | 4.716 | 46.1 | 97.8 | 35.085 | 0.072 |
| | 27 | 26.52 | 0.0096 | 0.6428 | 3.203 | 52.9 | 99.3 | 35.12 | 0.11 |
| | 08 | 26.94 | 0.0113 | 1.953 | 4.906 | 45.3 | 97.9 | 35.166 | 0.085 |
| | 07 | 27.02 | 0.0106 | 2.027 | 5.722 | 48.3 | 97.8 | 35.237 | 0.076 |
| # | 13 | 27.26 | 0.1806 | 2.630 | 6.406 | 2.8 | 97.2 | 35.354 | 0.074 |
| # | 06 | 29.16 | 1.915 | 8.328 | 0.427 | 0.27 | 92.1 | 35.87 | 0.58 |
| | **Mean age ± 2σ** | | n = 9 | MSWD = 1.62 | | 45.7 ± 9.6 | | **35.06** | **0.08** |
| | **#120 S-32,** Sanidine, J = 0.0007405 ± 0.06%, D = 1.003 ± 0.001, NM-192C, Lab# = 55932 | | | | | | | | |
| | 23 | 24.35 | 0.0136 | 2.664 | 4.645 | 37.4 | 96.8 | 31.207 | 0.080 |
| | 19 | 23.84 | 0.0110 | 0.8407 | 8.741 | 46.5 | 99.0 | 31.251 | 0.053 |
| | 05 | 23.73 | 0.0098 | 0.4530 | 4.076 | 51.9 | 99.4 | 31.260 | 0.084 |
| | 06 | 24.60 | 0.0109 | 3.348 | 5.726 | 46.8 | 96.0 | 31.277 | 0.071 |
| | 18 | 24.25 | 0.0108 | 2.152 | 14.449 | 47.3 | 97.4 | 31.282 | 0.054 |
| | 08 | 24.10 | 0.0104 | 1.642 | 6.600 | 49.2 | 98.0 | 31.284 | 0.060 |
| | 12 | 24.01 | 0.0120 | 1.252 | 4.394 | 42.5 | 98.5 | 31.312 | 0.077 |
| | 17 | 23.88 | 0.0102 | 0.7845 | 11.783 | 49.9 | 99.0 | 31.327 | 0.051 |
| | 25 | 24.47 | 0.0109 | 2.743 | 6.078 | 46.9 | 96.7 | 31.336 | 0.070 |
| | 02 | 24.41 | 0.0118 | 2.547 | 6.306 | 43.3 | 96.9 | 31.339 | 0.066 |
| | 21 | 24.72 | 0.0106 | 3.559 | 8.014 | 47.9 | 95.7 | 31.353 | 0.064 |
| | 13 | 26.02 | 0.0149 | 7.897 | 7.540 | 34.2 | 91.0 | 31.372 | 0.073 |
| | 10 | 24.12 | 0.0121 | 1.464 | 6.884 | 42.1 | 98.2 | 31.374 | 0.060 |
| | 26 | 24.27 | 0.0112 | 1.978 | 5.331 | 45.4 | 97.6 | 31.376 | 0.076 |
| | 22 | 23.86 | 0.0124 | 0.5513 | 8.060 | 41.1 | 99.3 | 31.381 | 0.068 |
| | 04 | 25.41 | 0.0125 | 5.828 | 7.239 | 40.9 | 93.2 | 31.381 | 0.066 |
| | 09 | 24.68 | 0.0116 | 3.315 | 8.499 | 44.2 | 96.0 | 31.385 | 0.057 |
| | 16 | 24.55 | 0.0127 | 2.831 | 10.680 | 40.0 | 96.6 | 31.402 | 0.083 |
| | 27 | 23.99 | 0.0121 | 0.9558 | 6.902 | 42.1 | 98.8 | 31.403 | 0.073 |
| | 11 | 23.88 | 0.0097 | 0.5277 | 4.839 | 52.8 | 99.4 | 31.428 | 0.072 |
| | 01 | 23.89 | 0.0102 | 0.4518 | 11.488 | 50.0 | 99.4 | 31.458 | 0.046 |
| | 03 | 24.06 | 0.0103 | 1.003 | 15.064 | 49.7 | 98.8 | 31.473 | 0.049 |
| | 07 | 25.41 | 0.0111 | 5.545 | 14.212 | 46.1 | 93.6 | 31.480 | 0.056 |
| | 14 | 23.85 | 0.0107 | 0.2782 | 7.667 | 47.6 | 99.7 | 31.480 | 0.053 |
| | 20 | 24.17 | 0.0123 | 1.307 | 16.481 | 41.5 | 98.4 | 31.504 | 0.068 |
| | 24 | 23.99 | 0.0102 | 0.6648 | 10.506 | 50.2 | 99.2 | 31.511 | 0.064 |
| # | 15 | 24.03 | 0.0125 | 0.4249 | 3.455 | 40.8 | 99.5 | 31.653 | 0.095 |
| | **Mean age ± 2σ** | | n=26 | MSWD=1.79 | | 45.3 ±9.1 | | **31.378** | **0.049** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#131 C-12,** Sanidine, J = 0.0007399 ± 0.06%, D = 1.003 ± 0.001, NM-192C, Lab# = 55933 | | | | | | | | |
| # | 04 | 25.07 | 1.985 | 13.17 | 0.058 | 0.26 | 85.1 | 28.3 | 3.8 |
| # | 14 | 24.53 | 2.952 | 10.06 | 0.038 | 0.17 | 88.9 | 28.9 | 5.8 |
| # | 20 | 24.73 | 2.080 | 6.141 | 0.071 | 0.25 | 93.4 | 30.6 | 2.5 |
| # | 22 | 42.97 | 3.461 | 65.62 | 0.041 | 0.15 | 55.5 | 31.7 | 4.5 |
| # | 12 | 29.07 | 3.486 | 16.43 | 0.166 | 0.15 | 84.3 | 32.5 | 1.4 |
| # | 05 | 25.47 | 4.147 | 4.200 | 0.083 | 0.12 | 96.5 | 32.6 | 2.6 |
| # | 10 | 25.32 | 0.0276 | 1.885 | 0.736 | 18.5 | 97.8 | 32.76 | 0.32 |
| | 09 | 25.44 | 0.0063 | 1.307 | 2.101 | 80.4 | 98.5 | 33.14 | 0.13 |
| | 03 | 25.54 | 0.0081 | 1.214 | 2.229 | 63.3 | 98.6 | 33.30 | 0.12 |
| # | 13 | 25.02 | 2.618 | –0.8914 | 0.128 | 0.19 | 101.9 | 33.8 | 1.7 |
| # | 01 | 25.70 | 0.0093 | 0.4614 | 3.864 | 55.0 | 99.5 | 33.808 | 0.086 |
| # | 21 | 25.93 | 0.0092 | 0.9268 | 1.004 | 55.5 | 98.9 | 33.93 | 0.22 |
| # | 18 | 24.26 | 3.052 | –3.7013 | 0.090 | 0.17 | 105.5 | 33.9 | 2.1 |
| # | 19 | 24.85 | 2.980 | –2.0105 | 0.085 | 0.17 | 103.4 | 34.0 | 2.2 |
| # | 28 | 25.94 | 0.0055 | 0.5989 | 1.762 | 92.7 | 99.3 | 34.06 | 0.14 |
| # | 25 | 25.96 | 0.2641 | 0.7452 | 0.752 | 1.9 | 99.2 | 34.06 | 0.30 |
| # | 02 | 26.33 | 0.0243 | 1.678 | 1.041 | 21.0 | 98.1 | 34.16 | 0.24 |
| # | 24 | 26.03 | 0.0093 | 0.5233 | 1.545 | 55.0 | 99.4 | 34.21 | 0.16 |
| # | 11 | 26.12 | 0.0085 | 0.7712 | 2.332 | 59.9 | 99.1 | 34.23 | 0.12 |
| # | 30 | 26.06 | 0.0037 | 0.5514 | 1.426 | 139.6 | 99.4 | 34.24 | 0.16 |
| # | 08 | 26.32 | 0.0161 | 1.413 | 0.798 | 31.6 | 98.4 | 34.24 | 0.30 |
| # | 15 | 26.71 | 0.0225 | 2.497 | 0.995 | 22.6 | 97.2 | 34.34 | 0.25 |
| # | 29 | 24.93 | 3.172 | –3.3436 | 0.137 | 0.16 | 105.0 | 34.7 | 1.4 |
| # | 07 | 26.94 | 0.0165 | 1.396 | 0.968 | 30.9 | 98.5 | 35.06 | 0.27 |
| # | 27 | 26.77 | 0.0299 | 0.4615 | 0.192 | 17.1 | 99.5 | 35.20 | 0.95 |
| # | 16 | 26.53 | 2.278 | –0.9873 | 0.069 | 0.22 | 101.8 | 35.7 | 2.8 |
| # | 17 | 25.73 | 3.246 | –4.0939 | 0.036 | 0.16 | 105.7 | 36.0 | 5.0 |
| # | 23 | 25.24 | 3.581 | –6.3886 | 0.033 | 0.14 | 108.7 | 36.3 | 5.7 |
| # | 06 | 33.36 | 2.124 | 1.912 | 0.050 | 0.24 | 98.8 | 43.5 | 4.3 |
| # | 26 | 28.04 | 3.176 | –16.0094 | 0.024 | 0.16 | 117.8 | 43.7 | 7.4 |
| | **Mean age ± 2σ** | | n = 2 | MSWD = 0.83 | | 71.9 ± 24.1 | | **33.22** | **0.18** |
| | **#132 C-7,** Sanidine, J = 0.0007449 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55946 | | | | | | | | |
| | 01 | 25.11 | 0.0061 | 0.5222 | 4.605 | 83.8 | 99.4 | 33.224 | 0.074 |
| | 13 | 25.72 | 0.0066 | 2.559 | 7.621 | 77.6 | 97.1 | 33.243 | 0.063 |
| | 10 | 26.00 | 0.0069 | 3.474 | 3.688 | 73.8 | 96.1 | 33.253 | 0.095 |
| | 14 | 25.22 | 0.0055 | 0.7930 | 5.690 | 92.5 | 99.1 | 33.271 | 0.067 |
| | 12 | 25.15 | 0.0067 | 0.5441 | 5.509 | 76.7 | 99.4 | 33.278 | 0.070 |
| | 15 | 25.08 | 0.0063 | 0.3074 | 4.238 | 81.4 | 99.6 | 33.278 | 0.087 |
| | 09 | 25.29 | 0.0066 | 0.9834 | 8.547 | 76.8 | 98.9 | 33.284 | 0.057 |
| | 08 | 25.24 | 0.0062 | 0.7747 | 8.185 | 82.0 | 99.1 | 33.300 | 0.055 |
| | 03 | 25.11 | 0.0072 | 0.3247 | 5.872 | 70.6 | 99.6 | 33.311 | 0.070 |
| | 06 | 25.37 | 0.0071 | 1.169 | 9.307 | 71.7 | 98.6 | 33.314 | 0.054 |
| | 04 | 25.41 | 0.0069 | 1.228 | 5.334 | 74.0 | 98.6 | 33.355 | 0.074 |
| | 02 | 25.52 | 0.0062 | 1.520 | 11.156 | 81.6 | 98.2 | 33.375 | 0.056 |
| | 05 | 25.59 | 0.0075 | 1.770 | 9.751 | 68.1 | 98.0 | 33.377 | 0.054 |
| | 11 | 25.38 | 0.0066 | 0.8919 | 9.596 | 77.4 | 99.0 | 33.443 | 0.055 |
| | 07 | 25.40 | 0.0064 | 0.7400 | 9.039 | 79.7 | 99.1 | 33.528 | 0.062 |
| | **Mean age ± 2σ** | | n = 15 | MSWD = 1.68 | | 77.8 ±12.2 | | **33.333** | **0.052** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#143 D89B,** Sanidine, J = 0.0007421 ± 0.05%, D = 1.003±0.001, NM-192D, Lab# = 55944 | | | | | | | | |
| | 03 | 22.45 | 0.0054 | 0.3578 | 3.474 | 94.5 | 99.5 | 29.671 | 0.088 |
| | 14 | 22.54 | 0.0046 | 0.6252 | 3.962 | 110.0 | 99.2 | 29.682 | 0.090 |
| | 12 | 22.53 | 0.0047 | 0.5180 | 3.603 | 108.6 | 99.3 | 29.709 | 0.091 |
| | 08 | 22.43 | 0.0050 | 0.1690 | 4.289 | 101.8 | 99.8 | 29.721 | 0.078 |
| | 15 | 22.46 | 0.0043 | 0.2036 | 4.626 | 117.9 | 99.7 | 29.735 | 0.072 |
| | 13 | 22.53 | 0.0051 | 0.4610 | 4.486 | 99.3 | 99.4 | 29.736 | 0.075 |
| | 09 | 23.53 | 0.0038 | 3.823 | 4.372 | 133.0 | 95.2 | 29.741 | 0.077 |
| | 07 | 22.56 | 0.0048 | 0.5094 | 7.233 | 106.4 | 99.3 | 29.757 | 0.057 |
| | 11 | 22.49 | 0.0049 | 0.2424 | 3.234 | 104.7 | 99.7 | 29.765 | 0.093 |
| | 10 | 22.59 | 0.0047 | 0.5165 | 9.142 | 107.9 | 99.3 | 29.793 | 0.050 |
| | 05 | 22.49 | 0.0050 | 0.1496 | 4.826 | 102.6 | 99.8 | 29.796 | 0.068 |
| | 02 | 22.56 | 0.0044 | 0.2477 | 4.380 | 116.4 | 99.7 | 29.863 | 0.071 |
| | 06 | 22.62 | 0.0057 | 0.4326 | 2.315 | 89.0 | 99.4 | 29.86 | 0.12 |
| | 04 | 22.57 | 0.0048 | 0.2662 | 2.033 | 106.0 | 99.7 | 29.87 | 0.13 |
| # | 01 | 24.85 | 2.661 | 0.0613 | 0.191 | 0.19 | 100.8 | 33.3 | 1.1 |
| | **Mean age ± 2σ** | | n = 14 | MSWD = 0.53 | | 107.0 ± 21.4 | | **29.764** | **0.049** |
| | **#151 D78B,** Sanidine, J =0.0007434 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55945 | | | | | | | | |
| | 09 | 22.42 | 0.0044 | 0.4385 | 3.862 | 117.1 | 99.4 | 29.649 | 0.085 |
| | 02 | 22.47 | 0.0055 | 0.5685 | 3.995 | 92.1 | 99.3 | 29.659 | 0.083 |
| | 15 | 22.43 | 0.0043 | 0.3747 | 4.554 | 118.7 | 99.5 | 29.681 | 0.076 |
| | 08 | 22.50 | 0.0053 | 0.5876 | 5.849 | 97.0 | 99.2 | 29.699 | 0.063 |
| | 05 | 22.40 | 0.0045 | 0.2466 | 5.391 | 113.0 | 99.7 | 29.699 | 0.062 |
| | 13 | 22.43 | 0.0061 | 0.3406 | 5.962 | 83.6 | 99.6 | 29.704 | 0.061 |
| | 06 | 22.46 | 0.0044 | 0.3874 | 5.477 | 114.7 | 99.5 | 29.728 | 0.058 |
| | 03 | 22.53 | 0.0045 | 0.5370 | 4.063 | 113.0 | 99.3 | 29.761 | 0.079 |
| | 01 | 22.48 | 0.0051 | 0.2539 | 6.398 | 99.5 | 99.7 | 29.796 | 0.060 |
| | 12 | 22.55 | 0.0044 | 0.4711 | 8.677 | 116.3 | 99.4 | 29.810 | 0.052 |
| | 07 | 22.54 | 0.0045 | 0.4113 | 6.838 | 113.8 | 99.5 | 29.817 | 0.056 |
| | 10 | 22.47 | 0.0047 | 0.1593 | 4.202 | 108.9 | 99.8 | 29.820 | 0.075 |
| | 04 | 22.49 | 0.0042 | 0.2466 | 5.413 | 120.8 | 99.7 | 29.822 | 0.062 |
| | 11 | 22.51 | 0.0046 | 0.1990 | 8.257 | 110.8 | 99.7 | 29.864 | 0.055 |
| | 14 | 22.75 | 0.0040 | 0.9074 | 8.373 | 126.3 | 98.8 | 29.906 | 0.055 |
| | **Mean age ± 2σ** | | n = 15 | MSWD = 1.51 | | 109.7 ± 23.3 | | **29.775** | **0.048** |
| | **#158 J-212,** Sanidine, J = 0.0007419±0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55942 | | | | | | | | |
| | 12 | 26.62 | 0.0023 | 1.094 | 3.478 | 224.3 | 98.8 | 34.852 | 0.097 |
| | 06 | 27.28 | 0.0036 | 3.329 | 3.152 | 141.9 | 96.4 | 34.86 | 0.11 |
| | 10 | 26.54 | 0.0032 | 0.4799 | 4.315 | 159.2 | 99.5 | 34.987 | 0.088 |
| | 15 | 26.67 | 0.0032 | 0.8116 | 4.694 | 157.3 | 99.1 | 35.027 | 0.079 |
| | 13 | 26.88 | 0.0031 | 1.518 | 2.549 | 162.4 | 98.3 | 35.03 | 0.11 |
| | 09 | 26.87 | 0.0027 | 1.363 | 3.965 | 190.9 | 98.5 | 35.085 | 0.090 |
| | 01 | 26.82 | 0.0025 | 1.136 | 3.862 | 204.6 | 98.7 | 35.100 | 0.085 |
| | 07 | 26.57 | 0.0032 | 0.2292 | 3.877 | 158.0 | 99.7 | 35.125 | 0.096 |
| | 02 | 26.68 | 0.0033 | 0.5903 | 3.218 | 153.1 | 99.3 | 35.13 | 0.10 |
| | 05 | 26.64 | 0.0029 | 0.4292 | 2.722 | 173.6 | 99.5 | 35.14 | 0.12 |
| | 04 | 26.92 | 0.0031 | 1.367 | 5.199 | 167.0 | 98.5 | 35.144 | 0.078 |
| | 14 | 26.88 | 0.0029 | 1.140 | 5.317 | 173.6 | 98.7 | 35.182 | 0.072 |
| | 08 | 26.77 | 0.0028 | 0.7029 | 3.599 | 183.7 | 99.2 | 35.210 | 0.092 |
| | 03 | 26.96 | 0.0022 | 1.296 | 5.183 | 231.0 | 98.6 | 35.223 | 0.078 |
| # | *11* | *27.11* | *0.0028* | *1.183* | *6.027* | *182.6* | *98.7* | *35.461* | *0.072* |
| | **Mean age ± 2σ** | | n = 14 | MSWD = 1.56 | | 177.2 ± 53.7 | | **35.090** | **0.069** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| | ID | $^{40}$Ar/$^{39}$Ar | $^{37}$Ar/$^{39}$Ar | $^{36}$Ar/$^{39}$Ar ($\times 10^{-3}$) | $^{39}$Ar$_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}$Ar* (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| | **#163 J-375,** Sanidine, J = 0.0007432 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55941 | | | | | | | | |
| | 15 | 44.43 | 0.2280 | 60.06 | 1.301 | 2.2 | 60.1 | 35.45 | 0.33 |
| | 03 | 36.61 | 0.2071 | 33.02 | 0.619 | 2.5 | 73.4 | 35.68 | 0.48 |
| | 11 | 62.34 | 0.1782 | 120.0 | 0.621 | 2.9 | 43.1 | 35.69 | 0.63 |
| | 01 | 40.23 | 0.3095 | 45.13 | 0.458 | 1.6 | 66.9 | 35.74 | 0.64 |
| | 04 | 30.89 | 0.2768 | 13.17 | 0.229 | 1.8 | 87.5 | 35.9 | 1.0 |
| | 09 | 29.34 | 0.1338 | 7.849 | 0.403 | 3.8 | 92.1 | 35.88 | 0.60 |
| | 08 | 42.63 | 0.2610 | 52.82 | 0.719 | 2.0 | 63.4 | 35.90 | 0.42 |
| | 14 | 33.65 | 0.1551 | 21.98 | 0.291 | 3.3 | 80.7 | 36.06 | 0.82 |
| | 10 | 32.08 | 0.2115 | 16.56 | 0.782 | 2.4 | 84.8 | 36.11 | 0.34 |
| | 05 | 36.81 | 0.2231 | 32.24 | 1.096 | 2.3 | 74.2 | 36.25 | 0.29 |
| | 07 | 36.49 | 0.2305 | 31.12 | 0.776 | 2.2 | 74.9 | 36.26 | 0.40 |
| | 06 | 41.72 | 0.1673 | 48.68 | 0.897 | 3.0 | 65.6 | 36.31 | 0.37 |
| | 12 | 48.06 | 0.5013 | 69.67 | 0.526 | 1.0 | 57.2 | 36.53 | 0.57 |
| | 13 | 42.25 | 0.1536 | 49.62 | 0.310 | 3.3 | 65.3 | 36.64 | 0.87 |
| | 02 | 37.65 | 0.2340 | 32.20 | 0.245 | 2.2 | 74.8 | 37.37 | 1.00 |
| | **Mean age ± 2σ** | | n = 15 | MSWD = 0.63 | | 2.4 ± 1.5 | | **36.04** | **0.24** |
| | **#169 WD8,** Sanidine, J = 0.0007414 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 55943 | | | | | | | | |
| # | *21* | *24.42* | *1.135* | *3.438* | *0.391* | *0.45* | *96.2* | *31.18* | *0.51* |
| # | *04* | *24.93* | *2.321* | *4.205* | *0.228* | *0.22* | *95.8* | *31.71* | *0.97* |
| # | *20* | *24.62* | *0.0167* | *2.221* | *1.012* | *30.5* | *97.3* | *31.77* | *0.20* |
| # | *25* | *24.99* | *3.238* | *4.108* | *0.245* | *0.16* | *96.2* | *31.95* | *0.79* |
| | 14 | 24.91 | 0.0217 | 2.259 | 1.591 | 23.5 | 97.3 | 32.15 | 0.16 |
| # | *30* | *24.99* | *2.392* | *3.192* | *0.169* | *0.21* | *97.0* | *32.2* | *1.1* |
| | 29 | 24.76 | 0.0419 | 1.466 | 0.969 | 12.2 | 98.3 | 32.26 | 0.22 |
| # | *12* | *24.53* | *0.3675* | *0.7886* | *1.409* | *1.4* | *99.2* | *32.26* | *0.18* |
| | 06 | 29.03 | 0.0241 | 15.68 | 2.227 | 21.1 | 84.0 | 32.34 | 0.16 |
| # | *19* | *24.53* | *1.515* | *0.8387* | *0.340* | *0.34* | *99.5* | *32.40* | *0.60* |
| | 27 | 24.89 | 0.0223 | 1.510 | 1.106 | 22.9 | 98.2 | 32.40 | 0.19 |
| | 07 | 25.80 | 0.0279 | 4.557 | 2.864 | 18.3 | 94.8 | 32.42 | 0.12 |
| | 24 | 24.86 | 0.0181 | 1.261 | 1.677 | 28.1 | 98.5 | 32.46 | 0.14 |
| | 13 | 24.71 | 0.0296 | 0.7086 | 6.268 | 17.3 | 99.2 | 32.486 | 0.063 |
| # | *03* | *24.84* | *0.0285* | *0.4766* | *5.387* | *17.9* | *99.4* | *32.743* | *0.072* |
| # | *02* | *24.83* | *1.472* | *0.1012* | *0.232* | *0.35* | *100.4* | *33.07* | *0.97* |
| # | *26* | *1936.2* | *0.0027* | *6465.5* | *0.017* | *186.1* | *1.3* | *34.0* | *27.8* |
| # | *22* | *752.6* | *0.0821* | *2439.1* | *0.033* | *6.2* | *4.2* | *42.1* | *10.6* |
| | **Mean age ± 2σ** | | n = 7 | MSWD = 0.79 | | 20.5 ± 10.3 | | **32.42** | **0.09** |
| | **#217 4EN1,** Sanidine, J = 0.0007449 ± 0.05%, D = 1.003 ± 0.001, NM-192C, Lab# = 55939 | | | | | | | | |
| | 10 | 25.21 | 0.0268 | 2.073 | 1.078 | 19.1 | 97.6 | 32.76 | 0.23 |
| | 03 | 25.28 | 0.0229 | 1.972 | 1.043 | 22.2 | 97.7 | 32.90 | 0.24 |
| | 13 | 24.92 | 0.0251 | 0.6946 | 1.616 | 20.3 | 99.2 | 32.92 | 0.16 |
| | 06 | 25.12 | 0.0223 | 1.095 | 1.340 | 22.8 | 98.7 | 33.02 | 0.20 |
| | 05 | 25.05 | 0.0353 | 0.7976 | 3.170 | 14.4 | 99.1 | 33.050 | 0.098 |
| | 04 | 25.10 | 0.0250 | 0.9600 | 1.969 | 20.4 | 98.9 | 33.06 | 0.13 |
| | 15 | 25.04 | 0.0211 | 0.7318 | 1.627 | 24.1 | 99.1 | 33.06 | 0.16 |
| | 11 | 25.03 | 0.0238 | 0.6847 | 2.334 | 21.4 | 99.2 | 33.07 | 0.12 |
| | 01 | 25.07 | 0.0256 | 0.8141 | 2.111 | 19.9 | 99.0 | 33.07 | 0.13 |
| | 14 | 25.21 | 0.0247 | 1.243 | 3.691 | 20.7 | 98.6 | 33.087 | 0.096 |
| | 09 | 25.09 | 0.0230 | 0.8048 | 1.345 | 22.2 | 99.1 | 33.09 | 0.20 |
| | 07 | 25.11 | 0.0229 | 0.6824 | 3.394 | 22.3 | 99.2 | 33.165 | 0.093 |
| | 08 | 25.21 | 0.0216 | 0.9446 | 1.911 | 23.6 | 98.9 | 33.20 | 0.14 |
| | 12 | 25.61 | 0.0222 | 2.021 | 1.766 | 23.0 | 97.7 | 33.31 | 0.16 |
| | 02 | 25.30 | 0.0271 | 0.8341 | 2.056 | 18.8 | 99.0 | 33.36 | 0.14 |
| | **Mean age ± 2σ** | | n = 15 | MSWD = 0.82 | | 21.0 ± 4.9 | | **33.101** | **0.076** |

(*continued*)

APPENDIX TABLE 3A. Ar-Ar DATA SINGLE CRYSTAL EXPERIMENTS (*continued*)

| ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ ($\times 10^{-3}$) | $^{39}Ar_K$ ($\times 10^{-15}$ mol) | K/Ca | $^{40}Ar^*$ (%) | Age (Ma) | ± 1σ (Ma) |
|---|---|---|---|---|---|---|---|---|
| **#220 CLLD,** Sanidine, J = 0.0007447 ± 0.05%, D = 1.003 ± 0.001, NM-192D, Lab# = 5940 | | | | | | | | |
| 04 | 25.33 | 0.0176 | 0.7088 | 2.903 | 29.0 | 99.2 | 33.44 | 0.11 |
| 07 | 25.35 | 0.0182 | 0.7023 | 2.272 | 28.0 | 99.2 | 33.47 | 0.13 |
| 14 | 25.26 | 0.0187 | 0.2986 | 3.926 | 27.2 | 99.7 | 33.511 | 0.091 |
| 06 | 25.48 | 0.0189 | 0.8989 | 2.631 | 27.0 | 99.0 | 33.57 | 0.11 |
| 12 | 25.45 | 0.0181 | 0.7307 | 2.809 | 28.1 | 99.2 | 33.58 | 0.12 |
| 02 | 25.54 | 0.0190 | 0.9152 | 2.653 | 26.8 | 98.9 | 33.64 | 0.12 |
| 03 | 25.38 | 0.0178 | 0.2695 | 2.576 | 28.7 | 99.7 | 33.68 | 0.12 |
| 05 | 25.43 | 0.0170 | 0.3987 | 3.248 | 30.1 | 99.5 | 33.695 | 0.097 |
| 11 | 25.39 | 0.0197 | 0.2618 | 4.841 | 25.9 | 99.7 | 33.695 | 0.074 |
| 01 | 25.46 | 0.0221 | 0.3721 | 4.652 | 23.1 | 99.6 | 33.740 | 0.083 |
| 09 | 25.58 | 0.0176 | 0.6807 | 4.275 | 29.0 | 99.2 | 33.774 | 0.079 |
| 10 | 25.43 | 0.0198 | 0.1498 | 3.799 | 25.7 | 99.8 | 33.787 | 0.089 |
| 08 | 25.58 | 0.0150 | 0.6528 | 2.362 | 34.0 | 99.3 | 33.79 | 0.12 |
| 15 | 25.48 | 0.0181 | 0.1504 | 5.054 | 28.1 | 99.8 | 33.853 | 0.070 |
| 13 | 25.61 | 0.0174 | 0.5365 | 6.522 | 29.4 | 99.4 | 33.876 | 0.067 |
| **Mean age ± 2σ** | | n = 15 | | MSWD = 2.14 | 28.0 ± 4.8 | | **33.712** | **0.076** |
| **#221 OWLD,** Sanidine, J = 0.0007454 ± 0.05%, D = 1.003 ± 0.001, NM-192C, Lab# = 55938 | | | | | | | | |
| # *13* | *25.33* | *0.0305* | *1.024* | *1.985* | *16.7* | *98.8* | *33.35* | *0.14* |
| # *12* | *25.59* | *0.0247* | *1.587* | *2.507* | *20.7* | *98.2* | *33.47* | *0.13* |
| 07 | 25.52 | 0.0382 | 0.9256 | 1.742 | 13.3 | 98.9 | 33.65 | 0.15 |
| 02 | 26.05 | 0.0387 | 2.704 | 3.881 | 13.2 | 96.9 | 33.647 | 0.089 |
| 11 | 25.46 | 0.0321 | 0.6319 | 3.183 | 15.9 | 99.3 | 33.68 | 0.10 |
| 10 | 25.46 | 0.0301 | 0.5793 | 3.270 | 16.9 | 99.3 | 33.700 | 0.096 |
| 05 | 26.39 | 0.0378 | 3.679 | 3.263 | 13.5 | 95.9 | 33.72 | 0.11 |
| 16 | 25.51 | 0.0297 | 0.6827 | 2.752 | 17.2 | 99.2 | 33.72 | 0.11 |
| 06 | 25.42 | 0.0654 | 0.3345 | 4.353 | 7.8 | 99.6 | 33.745 | 0.083 |
| 14 | 25.48 | 0.0283 | 0.3821 | 5.800 | 18.1 | 99.6 | 33.801 | 0.066 |
| 03 | 25.55 | 0.0282 | 0.5375 | 5.547 | 18.1 | 99.4 | 33.825 | 0.074 |
| 09 | 25.99 | 0.0303 | 2.027 | 1.915 | 16.9 | 97.7 | 33.83 | 0.16 |
| # *15* | *28.21* | *0.0343* | *9.154* | *7.334* | *14.9* | *90.4* | *33.976* | *0.077* |
| # *08* | *25.60* | *0.0295* | *0.2175* | *4.079* | *17.3* | *99.8* | *34.027* | *0.082* |
| # *04* | *25.74* | *0.0332* | *0.5733* | *4.281* | *15.4* | *99.4* | *34.065* | *0.082* |
| # *01* | *30.79* | *0.0387* | *17.53* | *7.547* | *13.2* | *83.2* | *34.121* | *0.092* |
| **Mean age ± 2σ** | | n = 10 | | MSWD = 0.51 | 15.1 ± 6.4 | | **33.744** | **0.067** |

*Note*: Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions. Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties. Mean age is weighted mean age of Taylor (1982). Mean age error is weighted error of the mean (Taylor, 1982), multiplied by the root of the MSWD where MSWD > 1, and also incorporates uncertainty in J factors and irradiation correction uncertainties. Decay constants and isotopic abundances after Steiger and Jäger (1977). # symbol preceding sample ID denotes analyses excluded from mean age calculations. Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.02 Ma. Decay Constant (LambdaK (total)) = 5.543e-10/a

Correction factors:

$(^{39}Ar/^{37}Ar)Ca$ = 0.0007 ± 2e–05

$(^{36}Ar/^{37}Ar)Ca$ = 0.00028 ± 1e–05

$(^{38}Ar/^{39}Ar)K$ = 0.013

$(^{40}Ar/^{39}Ar)K$ = 0 ± 0.0004

APPENDIX TABLE 3B. Ar-Ar DATA MULTIGRAIN MEASUREMENTS

| ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ | $^{39}Ar_K$ ($x10^{-3}$) | K/Ca ($x10^{-15}$ mol) | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|
| **#52 P18A,** L5:15, san,J = 0.0014368 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1772 | | | | | | | | |
| 01 | 11.26 | 0.0552 | 0.1217 | 15.155 | 9.2 | 99.7 | 28.799 | 0.056 |
| 03 | 19.70 | 0.0696 | 28.66 | 15.648 | 7.3 | 57.0 | 28.81 | 0.20 |
| 05 | 11.28 | 0.0577 | 0.1595 | 9.752 | 8.8 | 99.6 | 28.813 | 0.060 |
| 04 | 11.29 | 0.0588 | 0.1599 | 12.499 | 8.7 | 99.6 | 28.849 | 0.056 |
| 06 | 11.34 | 0.0762 | 0.2333 | 15.010 | 6.7 | 99.4 | 28.908 | 0.056 |
| 02 | 11.31 | 0.0598 | 0.1168 | 18.203 | 8.5 | 99.7 | 28.912 | 0.053 |
| 08 | 11.33 | 0.0643 | 0.1147 | 15.495 | 7.9 | 99.7 | 28.977 | 0.058 |
| 07 | 11.36 | 0.0654 | 0.2083 | 15.455 | 7.8 | 99.5 | 28.983 | 0.058 |
| **Mean age ± 2σ** | | n = 8 | MSWD = 1.45 | | 8.1 ± 1.7 | | **28.890** | **0.079** |
| **#109 S-4,** J11:15, plag,J = 0.0014434 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1761 | | | | | | | | |
| 05 | 13.04 | 0.4092 | 1.580 | 12.104 | 1.2 | 96.7 | 32.457 | 0.093 |
| 01 | 12.99 | 0.3802 | 1.366 | 10.825 | 1.3 | 97.1 | 32.479 | 0.086 |
| 02 | 12.87 | 0.4357 | 0.9248 | 8.487 | 1.2 | 98.1 | 32.525 | 0.082 |
| 03 | 13.13 | 0.4541 | 1.783 | 11.299 | 1.1 | 96.2 | 32.552 | 0.082 |
| 04 | 12.97 | 0.3587 | 1.122 | 12.878 | 1.4 | 97.7 | 32.621 | 0.088 |
| 06 | 12.98 | 0.3690 | 1.130 | 10.006 | 1.4 | 97.6 | 32.633 | 0.084 |
| **Mean age ± 2σ** | | n = 6 | MSWD = 0.68 | | 1.3 ± 0.2 | | **32.546** | **0.097** |
| **#119 S-31,** K1:15, plag,J = 0.0014489 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1762 | | | | | | | | |
| 01 | 12.45 | 0.4468 | 0.5370 | 10.240 | 1.1 | 99.0 | 31.861 | 0.072 |
| 02 | 12.74 | 0.4781 | 1.501 | 8.817 | 1.1 | 96.8 | 31.875 | 0.075 |
| 06 | 12.43 | 0.5250 | 0.4244 | 6.912 | 0.97 | 99.3 | 31.903 | 0.076 |
| 03 | 12.51 | 0.4132 | 0.6790 | 4.240 | 1.2 | 98.6 | 31.906 | 0.085 |
| 04 | 12.50 | 0.4617 | 0.6356 | 5.665 | 1.1 | 98.8 | 31.919 | 0.085 |
| 05 | 12.56 | 0.4437 | 0.7017 | 6.223 | 1.1 | 98.6 | 32.012 | 0.083 |
| **Mean age ± 2σ** | | n = 6 | MSWD = 0.44 | | 1.1 ± 0.2 | | **31.908** | **0.092** |
| **#149 D76B,** H2:15, Sanidine,J = 0.0014658 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1784 | | | | | | | | |
| 09 | 11.43 | 0.0052 | 0.1634 | 5.633 | 97.5 | 99.6 | 29.763 | 0.071 |
| 03 | 11.48 | 0.0047 | 0.3345 | 3.856 | 108.5 | 99.1 | 29.766 | 0.093 |
| 05 | 11.49 | 0.0044 | 0.2483 | 7.591 | 115.0 | 99.4 | 29.852 | 0.069 |
| 01 | 11.48 | 0.0056 | 0.2067 | 4.377 | 91.0 | 99.5 | 29.866 | 0.077 |
| 07 | 11.50 | 0.0039 | 0.2662 | 8.691 | 130.0 | 99.3 | 29.877 | 0.067 |
| 10 | 11.53 | 0.0061 | 0.3376 | 7.252 | 83.4 | 99.1 | 29.881 | 0.071 |
| 02 | 11.53 | 0.0050 | 0.3171 | 5.054 | 101.9 | 99.2 | 29.915 | 0.089 |
| 04 | 11.53 | 0.0055 | 0.2821 | 8.922 | 92.8 | 99.3 | 29.949 | 0.057 |
| 06 | 11.63 | 0.0043 | 0.5920 | 5.501 | 119.3 | 98.5 | 29.966 | 0.095 |
| **Mean age ± 2σ** | | n = 9 | MSWD = 0.84 | | 104.4 ± 30.1 | | **29.874** | **0.078** |
| **#155 J-140,** H8:15, Sanidine,J = 0.0014487 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1788 | | | | | | | | |
| 10 | 11.63 | 0.0081 | 0.3524 | 3.037 | 63.0 | 99.1 | 29.785 | 0.088 |
| 04 | 11.61 | 0.0057 | 0.2791 | 7.448 | 89.7 | 99.3 | 29.793 | 0.071 |
| 02 | 11.58 | 0.0070 | 0.1458 | 5.447 | 73.2 | 99.6 | 29.813 | 0.084 |
| 07 | 11.63 | 0.0083 | 0.3141 | 7.779 | 61.5 | 99.2 | 29.833 | 0.065 |
| 09 | 11.59 | 0.0091 | 0.1713 | 5.094 | 56.3 | 99.6 | 29.834 | 0.072 |
| 03 | 11.60 | 0.0066 | 0.1879 | 6.485 | 77.3 | 99.5 | 29.835 | 0.071 |
| 06 | 11.63 | 0.0079 | 0.2539 | 13.036 | 64.3 | 99.4 | 29.866 | 0.064 |
| 01 | 11.63 | 0.0069 | 0.2123 | 7.020 | 74.0 | 99.5 | 29.897 | 0.075 |
| 08 | 11.63 | 0.0075 | 0.2122 | 8.556 | 67.9 | 99.5 | 29.900 | 0.064 |
| 05 | 11.68 | 0.0063 | 0.2685 | 12.070 | 81.0 | 99.3 | 29.989 | 0.061 |
| # *11* | *11.73* | *0.0084* | *0.2064* | *4.385* | *61.1* | *99.5* | *30.152* | *0.069* |
| **Mean age ± 2σ** | | n = 10 | MSWD = 0.83 | | 70.8 ± 20.3 | | **29.863** | **0.076** |
| **#158 J-212,** L7:15, Sanidine,J = 0.0014293 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1795 | | | | | | | | |
| 06 | 13.92 | 0.0085 | 1.210 | 2.353 | 59.7 | 97.4 | 34.57 | 0.11 |
| 04 | 13.74 | 0.0038 | 0.2279 | 2.383 | 133.2 | 99.5 | 34.84 | 0.11 |
| 10 | 13.78 | 0.0039 | 0.1754 | 9.643 | 130.0 | 99.6 | 34.967 | 0.077 |
| 02 | 13.79 | 0.0038 | 0.1656 | 4.992 | 134.8 | 99.6 | 35.003 | 0.086 |
| 07 | 13.83 | 0.0033 | 0.2953 | 5.925 | 154.5 | 99.4 | 35.012 | 0.076 |
| 05 | 14.18 | 0.0046 | 1.263 | 3.689 | 111.9 | 97.4 | 35.187 | 0.093 |
| 01 | 13.97 | 0.0027 | 0.4945 | 5.316 | 186.0 | 99.0 | 35.230 | 0.087 |
| 09 | 13.88 | 0.0026 | 0.1262 | 3.816 | 199.3 | 99.7 | 35.267 | 0.087 |
| 08 | 13.88 | 0.0028 | 0.1123 | 5.372 | 184.5 | 99.8 | 35.289 | 0.093 |
| 03 | 13.93 | 0.0045 | 0.1506 | 5.183 | 114.2 | 99.7 | 35.376 | 0.090 |
| **Mean age ± 2σ** | | n = 10 | MSWD = 6.03 | | 140.8 ± 84.0 | | **35.09** | **0.16** |

(*continued*)

APPENDIX TABLE 3B. Ar-Ar DATA MULTIGRAIN MEASUREMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ | $^{39}Ar_K$ ($x10^{-3}$) | K/Ca ($x10^{-15}$ mol) | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| **#170 W-200,** K11:15, san,J = 0.0014393 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1769 | | | | | | | | | |
| | 05 | 12.77 | 0.0174 | 0.1200 | 8.648 | 29.3 | 99.7 | 32.691 | 0.073 |
| | 03 | 13.18 | 0.0177 | 1.471 | 8.114 | 28.7 | 96.7 | 32.718 | 0.071 |
| | 02 | 12.82 | 0.0173 | 0.2412 | 8.270 | 29.5 | 99.5 | 32.724 | 0.069 |
| | 06 | 12.81 | 0.0190 | 0.1574 | 8.769 | 26.9 | 99.6 | 32.754 | 0.067 |
| | 07 | 13.14 | 0.0183 | 1.266 | 7.694 | 27.9 | 97.2 | 32.764 | 0.072 |
| | 01 | 12.80 | 0.0175 | 0.1091 | 7.456 | 29.2 | 99.8 | 32.773 | 0.075 |
| | 09 | 13.13 | 0.0174 | 1.135 | 10.434 | 29.4 | 97.5 | 32.852 | 0.075 |
| | 10 | 13.20 | 0.0174 | 1.347 | 6.644 | 29.2 | 97.0 | 32.855 | 0.075 |
| | 04 | 12.92 | 0.0140 | 0.3643 | 4.355 | 36.4 | 99.2 | 32.883 | 0.078 |
| | 08 | 12.86 | 0.0160 | 0.1158 | 6.088 | 31.9 | 99.7 | 32.929 | 0.070 |
| | **Mean age ± 2σ** | | n = 10 | MSWD = 1.22 | | 29.8 ± 5.3 | | **32.791** | **0.085** |
| **#171 WF-1,** 10-20 XSTALS SAN, J = 0.000735 ± 0.14%, D = 1.0078 ± 0.0016, NM-20,Lab# = 2012 | | | | | | | | | |
| | 04 | 25.09 | 0.0197 | 0.9817 | 2.380 | 25.9 | 98.8 | 32.565 | 0.083 |
| | 07 | 25.09 | 0.0169 | 0.9626 | 2.373 | 30.2 | 98.9 | 32.566 | 0.078 |
| | 08 | 25.11 | 0.0150 | 0.9349 | 1.734 | 33.9 | 98.9 | 32.61 | 0.10 |
| | 10 | 25.28 | 0.0164 | 1.495 | 2.852 | 31.1 | 98.3 | 32.608 | 0.089 |
| | 02 | 25.15 | 0.0173 | 0.9908 | 6.361 | 29.5 | 98.8 | 32.642 | 0.081 |
| | 06 | 25.20 | 0.0163 | 1.060 | 3.088 | 31.3 | 98.8 | 32.672 | 0.079 |
| | 05 | 25.45 | 0.0175 | 1.794 | 3.031 | 29.2 | 97.9 | 32.718 | 0.082 |
| | 03 | 25.18 | 0.0174 | 0.4866 | 3.214 | 29.3 | 99.4 | 32.874 | 0.077 |
| | 09 | 25.32 | 0.0161 | 0.9657 | 3.136 | 31.7 | 98.9 | 32.87 | 0.10 |
| | 01 | 25.36 | 0.0156 | 1.032 | 4.717 | 32.7 | 98.8 | 32.894 | 0.075 |
| | **Mean age ± 2σ** | | n = 10 | MSWD = 2.53 | | 30.5 ± 4.5 | | **32.70** | **0.12** |
| **#175 I-521,** E5:15, Anorthoclase,J = 0.0014515 ± 0.10%, D = 1.0093 ± 0.0019, NM-15,Lab# = 1722 | | | | | | | | | |
| | 06 | 13.04 | 0.0707 | 1.117 | 1.774 | 7.2 | 97.5 | 32.91 | 0.15 |
| | 03 | 12.92 | 0.0851 | 0.5652 | 1.481 | 6.0 | 98.8 | 33.02 | 0.12 |
| | 04 | 12.95 | 0.0792 | 0.5547 | 2.047 | 6.4 | 98.8 | 33.10 | 0.10 |
| | 08 | 12.93 | 0.0830 | 0.4862 | 3.382 | 6.1 | 98.9 | 33.109 | 0.094 |
| | 05 | 12.91 | 0.0680 | 0.3847 | 1.103 | 7.5 | 99.2 | 33.13 | 0.14 |
| | 01 | 13.00 | 0.0935 | 0.5772 | 3.787 | 5.5 | 98.7 | 33.230 | 0.099 |
| | 02 | 13.02 | 0.0894 | 0.4767 | 3.414 | 5.7 | 99.0 | 33.36 | 0.10 |
| | 07 | 13.00 | 0.0713 | 0.2271 | 1.435 | 7.2 | 99.5 | 33.49 | 0.12 |
| | **Mean age ± 2σ** | | n = 8 | MSWD = 2.40 | | 6.5 ± 1.5 | | **33.19** | **0.14** |
| **#180 I-470,** H5:15, Sanidine,J = 0.0014541 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1786 | | | | | | | | | |
| # | *02* | *11.97* | *0.0053* | *0.3022* | *10.392* | *96.7* | *99.3* | *30.824* | *0.058* |
| | 04 | 14.72 | 0.0004 | 5.027 | 10.253 | 1165.1 | 89.9 | 34.30 | 0.10 |
| | 07 | 13.33 | -0.0006 | 0.0283 | 4.256 | - | 99.9 | 34.53 | 0.10 |
| | 03 | 13.38 | 0.0009 | 0.0016 | 2.518 | 556.0 | 100.0 | 34.67 | 0.11 |
| | 01 | 13.39 | -0.0003 | 0.0176 | 6.369 | - | 100.0 | 34.683 | 0.075 |
| | 05 | 14.56 | 0.0008 | 3.992 | 10.830 | 677.6 | 91.9 | 34.690 | 0.085 |
| | 06 | 13.45 | -0.0005 | 0.0726 | 7.001 | - | 99.8 | 34.801 | 0.081 |
| | 08 | 13.49 | 0.0016 | 0.0822 | 7.685 | 322.1 | 99.8 | 34.908 | 0.077 |
| | **Mean age ± 2σ** | | n = 7 | MSWD = 4.52 | | 680.2 ± 537.2 | | **34.7** | **0.2** |
| **#182 DZ-31,** H1:15, Sanidine,J = 0.0014662 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1783 | | | | | | | | | |
| | 04 | 11.40 | 0.1147 | 0.3540 | 3.235 | 4.4 | 99.2 | 29.569 | 0.088 |
| | 07 | 11.85 | 0.1094 | 1.479 | 1.812 | 4.7 | 96.4 | 29.88 | 0.10 |
| | 09 | 11.44 | 0.1130 | 0.0688 | 1.839 | 4.5 | 99.9 | 29.89 | 0.10 |
| | 08 | 11.53 | 0.1219 | 0.3841 | 2.067 | 4.2 | 99.1 | 29.904 | 0.090 |
| | 06 | 11.51 | 0.1209 | 0.2337 | 2.157 | 4.2 | 99.5 | 29.965 | 0.099 |
| | 10 | 11.65 | 0.1034 | 0.6784 | 4.489 | 4.9 | 98.3 | 29.982 | 0.088 |
| | 05 | 11.79 | 0.1161 | 0.7719 | 4.563 | 4.4 | 98.1 | 30.262 | 0.099 |
| # | *02* | *11.94* | *0.1094* | *0.4282* | *1.854* | *4.7* | *99.0* | *30.929* | *0.094* |
| # | *01* | *12.63* | *0.0676* | *1.012* | *3.449* | *7.6* | *97.7* | *32.265* | *0.088* |
| # | *03* | *54.02* | *0.1229* | *1.084* | *3.331* | *4.1* | *99.4* | *136.68* | *0.37* |
| | **Mean age ± 2σ** | | n = 7 | MSWD = 4.81 | | 4.5 ± 0.5 | | **29.91** | **0.17** |

(*continued*)

APPENDIX TABLE 3B. Ar-Ar DATA MULTIGRAIN MEASUREMENTS (*continued*)

| ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ | $^{39}Ar_K$ ($x10^{-3}$) | K/Ca ($x10^{-15}$ mol) | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|
| **#184 I-478,** H7:15, Sanidine,J = 0.0014483 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1787 | | | | | | | | |
| 09 | 13.60 | 0.0249 | 1.640 | 2.011 | 20.5 | 96.4 | 33.86 | 0.11 |
| 06 | 13.53 | 0.0217 | 1.408 | 11.836 | 23.5 | 96.9 | 33.867 | 0.073 |
| 07 | 14.76 | 0.0230 | 5.557 | 6.526 | 22.2 | 88.9 | 33.88 | 0.12 |
| 01 | 15.04 | 0.0213 | 6.454 | 2.510 | 24.0 | 87.3 | 33.90 | 0.12 |
| 02 | 13.33 | 0.0266 | 0.6761 | 12.588 | 19.2 | 98.5 | 33.913 | 0.069 |
| 05 | 13.77 | 0.0269 | 2.127 | 4.298 | 18.9 | 95.4 | 33.93 | 0.10 |
| 03 | 13.84 | 0.0247 | 2.313 | 5.351 | 20.7 | 95.1 | 33.963 | 0.092 |
| 08 | 13.84 | 0.0203 | 2.321 | 8.217 | 25.2 | 95.0 | 33.968 | 0.084 |
| 04 | 13.67 | 0.0284 | 1.693 | 3.115 | 17.9 | 96.4 | 34.006 | 0.100 |
| **Mean age ± 2σ** | | n = 9 | MSWD = 0.28 | | 21.3 ± 5.0 | | **33.921** | **0.092** |
| **#185 I-164,** L1:15, san,J = 0.0014372 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1770 | | | | | | | | |
| 06 | 12.98 | 0.1003 | 0.4540 | 5.642 | 5.1 | 99.0 | 32.934 | 0.071 |
| 01 | 12.97 | 0.1059 | 0.3649 | 3.323 | 4.8 | 99.2 | 32.977 | 0.086 |
| 07 | 13.01 | 0.1033 | 0.3460 | 3.152 | 4.9 | 99.3 | 33.105 | 0.090 |
| 03 | 13.01 | 0.0897 | 0.3119 | 3.890 | 5.7 | 99.3 | 33.118 | 0.076 |
| 08 | 13.19 | 0.1499 | 0.9305 | 2.696 | 3.4 | 98.0 | 33.141 | 0.081 |
| 09 | 13.17 | 0.1109 | 0.7791 | 3.622 | 4.6 | 98.3 | 33.185 | 0.085 |
| 04 | 13.11 | 0.0955 | 0.5611 | 2.672 | 5.3 | 98.8 | 33.196 | 0.085 |
| 02 | 13.07 | 0.1066 | 0.4116 | 3.192 | 4.8 | 99.1 | 33.203 | 0.076 |
| 10 | 13.26 | 0.1012 | 1.040 | 6.891 | 5.0 | 97.7 | 33.226 | 0.074 |
| 05 | 13.08 | 0.1053 | 0.3533 | 5.794 | 4.8 | 99.3 | 33.280 | 0.079 |
| **Mean age ± 2σ** | | n = 10 | MSWD = 2.00 | | 4.9 ± 1.2 | | **33.135** | **0.099** |
| **#187 VG-7B,** K10:15, san,J = 0.0014361 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1768 | | | | | | | | |
| 09 | 14.34 | 0.0270 | 1.866 | 11.105 | 18.9 | 96.2 | 35.313 | 0.080 |
| 05 | 14.12 | 0.0321 | 1.074 | 7.507 | 15.9 | 97.8 | 35.343 | 0.085 |
| 08 | 13.96 | 0.0255 | 0.4994 | 8.371 | 20.0 | 99.0 | 35.368 | 0.079 |
| 06 | 14.01 | 0.0269 | 0.6187 | 6.439 | 18.9 | 98.7 | 35.393 | 0.076 |
| 07 | 13.94 | 0.0260 | 0.3570 | 5.279 | 19.6 | 99.3 | 35.420 | 0.076 |
| 10 | 14.10 | 0.0244 | 0.8196 | 7.781 | 20.9 | 98.3 | 35.475 | 0.077 |
| 02 | 13.94 | 0.0244 | 0.2784 | 6.944 | 20.9 | 99.4 | 35.483 | 0.088 |
| 04 | 14.03 | 0.0247 | 0.5625 | 10.155 | 20.7 | 98.8 | 35.494 | 0.085 |
| 03 | 14.22 | 0.0229 | 1.185 | 4.970 | 22.3 | 97.5 | 35.505 | 0.092 |
| 01 | 14.12 | 0.0251 | 0.8077 | 6.252 | 20.3 | 98.3 | 35.534 | 0.086 |
| **Mean age ± 2σ** | | n = 10 | MSWD = 0.83 | | 19.8 ± 3.4 | | **35.428** | **0.090** |
| **#188 CM-634,** G7:15, Sanidine,J = 0.0014475 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1779 | | | | | | | | |
| # *10* | *15.45* | *0.0835* | *10.15* | *0.761* | *6.1* | *80.6* | *32.16* | *0.26* |
| # *08* | *17.84* | *0.1203* | *17.78* | *0.839* | *4.2* | *70.5* | *32.51* | *0.26* |
| 09 | 17.16 | 0.1096 | 14.54 | 1.068 | 4.7 | 75.0 | 33.22 | 0.23 |
| 03 | 16.90 | 0.1182 | 13.65 | 4.341 | 4.3 | 76.2 | 33.24 | 0.16 |
| 01 | 17.35 | 0.1101 | 15.05 | 3.244 | 4.6 | 74.4 | 33.33 | 0.15 |
| 04 | 16.93 | 0.1062 | 13.29 | 3.485 | 4.8 | 76.8 | 33.57 | 0.16 |
| 02 | 16.92 | 0.1057 | 13.27 | 6.977 | 4.8 | 76.8 | 33.58 | 0.14 |
| 05 | 18.47 | 0.1160 | 18.35 | 1.197 | 4.4 | 70.6 | 33.69 | 0.22 |
| 07 | 17.77 | 0.1129 | 15.92 | 3.422 | 4.5 | 73.5 | 33.75 | 0.16 |
| 06 | 16.06 | 0.1064 | 9.755 | 3.876 | 4.8 | 82.1 | 34.04 | 0.13 |
| **Mean age ± 2σ** | | n = 8 | MSWD = 3.26 | | 4.6 ± 0.4 | | **33.59** | **0.22** |
| **#198 J-ER,** H10:15, Sanidine,J = 0.0014557 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1789 | | | | | | | | |
| 02 | 14.21 | 0.0108 | 2.399 | 6.291 | 47.5 | 95.0 | 35.03 | 0.10 |
| 03 | 14.38 | 0.0125 | 2.774 | 7.222 | 40.8 | 94.3 | 35.199 | 0.088 |
| 04 | 14.04 | 0.0118 | 1.612 | 5.767 | 43.3 | 96.6 | 35.199 | 0.086 |
| 01 | 14.42 | 0.0119 | 2.878 | 8.613 | 42.8 | 94.1 | 35.201 | 0.086 |
| 06 | 13.85 | 0.0128 | 0.9247 | 7.354 | 39.8 | 98.0 | 35.217 | 0.098 |
| 05 | 13.78 | 0.0130 | 0.6123 | 6.322 | 39.2 | 98.7 | 35.280 | 0.091 |
| **Mean age ± 2σ** | | n = 6 | MSWD = 0.73 | | 42.2 ± 6.1 | | **35.19** | **0.10** |

(*continued*)

APPENDIX TABLE 3B. Ar-Ar DATA MULTIGRAIN MEASUREMENTS (*continued*)

| | ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ | $^{39}Ar_K$ ($x10^{-3}$) | K/Ca ($x10^{-15}$ mol) | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| **# 201 CG-BL,** E7:15, Anorthoclase,J = 0.0014468 ± 0.10%, D = 1.0093 ± 0.0019, NM-15,Lab# = 1723 | | | | | | | | | |
| | 05 | 14.73 | 0.0223 | 0.5008 | 3.297 | 22.9 | 99.0 | 37.58 | 0.11 |
| | 02 | 14.75 | 0.0226 | 0.5678 | 12.685 | 22.5 | 98.9 | 37.589 | 0.093 |
| | 08 | 14.70 | 0.0240 | 0.2720 | 4.645 | 21.3 | 99.5 | 37.68 | 0.10 |
| | 04 | 14.68 | 0.0188 | 0.1697 | 3.697 | 27.1 | 99.7 | 37.71 | 0.11 |
| | 07 | 14.87 | 0.0237 | 0.7854 | 3.421 | 21.5 | 98.4 | 37.74 | 0.13 |
| | 01 | 14.81 | 0.0265 | 0.5571 | 6.074 | 19.2 | 98.9 | 37.761 | 0.099 |
| | 03 | 14.76 | 0.0233 | 0.1146 | 3.681 | 21.9 | 99.8 | 37.96 | 0.11 |
| # | *06* | *15.10* | *0.0206* | *0.2298* | *4.723* | *24.7* | *99.6* | *38.75* | *0.11* |
| | **Mean age ± 2σ** | n = 7 | | MSWD = 1.38 | | 22.4 ± 4.8 | | **37.71** | **0.12** |
| **#207 RED,** 10-20 XSTALS SAN, J = 0.0007339 ± 0.14%, D = 1.0078 ± 0.0016, NM-20,Lab# = 2011 | | | | | | | | | |
| | 07 | 31.44 | 0.0352 | 0.9911 | 2.993 | 14.5 | 99.1 | 40.749 | 0.091 |
| | 04 | 31.48 | 0.0154 | 1.089 | 4.444 | 33.1 | 99.0 | 40.761 | 0.087 |
| | 05 | 31.97 | 0.0298 | 2.728 | 4.047 | 17.1 | 97.5 | 40.778 | 0.089 |
| | 09 | 31.38 | 0.0675 | 0.6637 | 3.447 | 7.6 | 99.4 | 40.801 | 0.082 |
| | 02 | 31.36 | 0.0910 | 0.5036 | 4.317 | 5.6 | 99.5 | 40.830 | 0.086 |
| | 10 | 32.44 | 0.1264 | 3.929 | 2.133 | 4.0 | 96.4 | 40.92 | 0.11 |
| | 03 | 33.07 | 0.0737 | 6.015 | 2.078 | 6.9 | 94.6 | 40.94 | 0.12 |
| | 08 | 31.66 | 0.0671 | 1.164 | 3.106 | 7.6 | 98.9 | 40.97 | 0.10 |
| | 06 | 31.56 | 0.0992 | 0.6870 | 2.366 | 5.1 | 99.4 | 41.03 | 0.11 |
| | **Mean age ± 2σ** | n = 9 | | MSWD = 1.06 | | 11.3 ± 18.5 | | **40.85** | **0.13** |
| **#208 RP,** J10:15, san,J = 0.0014402 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1760 | | | | | | | | | |
| | 01 | 13.31 | 0.0723 | 0.2972 | 9.901 | 7.1 | 99.4 | 33.955 | 0.075 |
| | 04 | 13.26 | 0.0365 | 0.1053 | 11.220 | 14.0 | 99.8 | 33.976 | 0.083 |
| | 06 | 13.58 | 0.0641 | 1.115 | 8.465 | 8.0 | 97.6 | 34.029 | 0.087 |
| | 03 | 13.40 | 0.0583 | 0.5011 | 9.977 | 8.8 | 98.9 | 34.048 | 0.078 |
| | 02 | 13.37 | 0.0551 | 0.3926 | 9.055 | 9.3 | 99.2 | 34.048 | 0.079 |
| | 09 | 13.31 | 0.0683 | 0.1813 | 7.383 | 7.5 | 99.6 | 34.059 | 0.084 |
| | 07 | 13.33 | 0.0669 | 0.2143 | 6.943 | 7.6 | 99.6 | 34.071 | 0.083 |
| | 08 | 13.31 | 0.0941 | 0.1151 | 5.318 | 5.4 | 99.8 | 34.103 | 0.083 |
| | 05 | 13.40 | 0.0543 | 0.4299 | 3.497 | 9.4 | 99.1 | 34.104 | 0.087 |
| | 10 | 13.45 | 0.0520 | 0.5738 | 13.531 | 9.8 | 98.8 | 34.123 | 0.077 |
| | **Mean age ± 2σ** | n = 10 | | MSWD = 0.47 | | 8.7 ± 4.6 | | **34.050** | **0.087** |
| **#209 SC11-9,** K7:15, san,J = 0.0014408 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1766 | | | | | | | | | |
| | 08 | 13.85 | 0.0118 | 0.5683 | 10.628 | 43.3 | 98.8 | 35.140 | 0.085 |
| | 06 | 13.75 | 0.0113 | 0.1566 | 7.510 | 45.3 | 99.7 | 35.187 | 0.084 |
| | 03 | 13.76 | 0.0132 | 0.1483 | 7.927 | 38.5 | 99.7 | 35.229 | 0.087 |
| | 10 | 13.86 | 0.0129 | 0.4538 | 8.361 | 39.4 | 99.0 | 35.242 | 0.089 |
| | 01 | 13.82 | 0.0110 | 0.3381 | 4.992 | 46.5 | 99.3 | 35.245 | 0.097 |
| | 07 | 13.77 | 0.0117 | 0.1408 | 6.306 | 43.8 | 99.7 | 35.268 | 0.083 |
| | 04 | 13.77 | 0.0101 | 0.1146 | 8.022 | 50.7 | 99.8 | 35.285 | 0.093 |
| | 09 | 13.85 | 0.0127 | 0.2636 | 7.394 | 40.1 | 99.4 | 35.367 | 0.081 |
| | 02 | 13.94 | 0.0109 | 0.4516 | 6.403 | 46.6 | 99.0 | 35.463 | 0.090 |
| | 05 | 13.92 | 0.0113 | 0.3459 | 6.043 | 45.1 | 99.3 | 35.495 | 0.088 |
| | **Mean age ± 2σ** | n = 10 | | MSWD = 1.75 | | 43.9 ± 7.5 | | **35.29** | **0.10** |
| **#210 SC11-10,** san, multi crystals,J = 0.0009096 ± 0.22%, D = 1.0062 ± 0.0015, NM-8,Lab# = 721 | | | | | | | | | |
| | 01 | 21.86 | 0.0336 | 0.1332 | 3.869 | 15.2 | 99.8 | 35.431 | 0.080 |
| | 05 | 21.88 | 0.0353 | 0.1188 | 1.528 | 14.5 | 99.9 | 35.472 | 0.090 |
| | 03 | 21.95 | 0.0408 | 0.2761 | 2.312 | 12.5 | 99.6 | 35.505 | 0.094 |
| | 04 | 21.92 | 0.0343 | 0.1516 | 2.618 | 14.9 | 99.8 | 35.515 | 0.093 |
| | 02 | 21.99 | 0.0354 | 0.1601 | 2.843 | 14.4 | 99.8 | 35.624 | 0.087 |
| | 07 | 22.05 | 0.0340 | 0.3272 | 2.393 | 15.0 | 99.6 | 35.636 | 0.099 |
| | 06 | 22.03 | 0.0368 | –0.0195 | 2.699 | 13.9 | 100.0 | 35.774 | 0.090 |
| | 08 | 22.00 | 0.0342 | –0.4019 | 1.509 | 14.9 | 100.6 | 35.91 | 0.11 |
| | **Mean age ± 2σ** | n = 8 | | MSWD = 2.82 | | 14.4 ± 1.7 | | **35.59** | **0.19** |

(*continued*)

APPENDIX TABLE 3B. Ar-Ar DATA MULTIGRAIN MEASUREMENTS (*continued*)

| ID | $^{40}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{36}Ar/^{39}Ar$ | $^{39}Ar_K$ ($x10^{-3}$) | K/Ca ($x10^{-15}$ mol) | $^{40}Ar^*$ (%) | Age (Ma) | ±1σ (Ma) |
|---|---|---|---|---|---|---|---|---|
| **#211 EC1,** H4:15, Sanidine,J = 0.0014588 ± 0.10%, D = 1.0071 ± 0.0016, nm-15,Lab# = 1785 | | | | | | | | |
| 01 | 13.52 | 0.0067 | 0.1653 | 8.302 | 75.6 | 99.6 | 35.038 | 0.090 |
| 09 | 13.62 | 0.0051 | 0.4302 | 8.859 | 99.9 | 99.1 | 35.089 | 0.070 |
| 03 | 13.63 | 0.0052 | 0.4184 | 13.444 | 98.0 | 99.1 | 35.124 | 0.075 |
| 05 | 14.00 | 0.0060 | 1.672 | 13.296 | 85.4 | 96.5 | 35.127 | 0.079 |
| 07 | 13.63 | 0.0057 | 0.3804 | 9.236 | 88.8 | 99.2 | 35.152 | 0.071 |
| 04 | 14.41 | 0.0063 | 2.998 | 10.301 | 80.6 | 93.8 | 35.171 | 0.086 |
| 02 | 13.57 | 0.0047 | 0.1268 | 10.182 | 108.6 | 99.7 | 35.179 | 0.067 |
| 06 | 13.60 | 0.0059 | 0.1972 | 8.711 | 86.5 | 99.6 | 35.207 | 0.076 |
| 08 | 13.73 | 0.0033 | 0.5454 | 3.405 | 152.6 | 98.8 | 35.29 | 0.11 |
| **Mean age ± 2σ** | | n = 9 | MSWD = 0.60 | | 97.3 ± 46.3 | | **35.147** | **0.089** |
| **#214 RND1,** J8:15, san,J = 0.00144 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1759 | | | | | | | | |
| 01 | 13.66 | 0.0267 | 0.5199 | 3.019 | 19.1 | 98.9 | 34.68 | 0.11 |
| 07 | 13.62 | 0.0259 | 0.3617 | 9.540 | 19.7 | 99.2 | 34.701 | 0.088 |
| 09 | 13.68 | 0.0269 | 0.3327 | 6.550 | 18.9 | 99.3 | 34.879 | 0.082 |
| 08 | 13.69 | 0.0295 | 0.3465 | 7.086 | 17.3 | 99.3 | 34.880 | 0.079 |
| 02 | 13.69 | 0.0267 | 0.3550 | 3.805 | 19.1 | 99.2 | 34.884 | 0.097 |
| 05 | 13.69 | 0.0272 | 0.3231 | 6.542 | 18.7 | 99.3 | 34.903 | 0.086 |
| 10 | 13.74 | 0.0299 | 0.4885 | 3.820 | 17.0 | 99.0 | 34.905 | 0.094 |
| 03 | 13.70 | 0.0275 | 0.3438 | 10.158 | 18.5 | 99.3 | 34.905 | 0.084 |
| 06 | 13.67 | 0.0262 | 0.2399 | 4.551 | 19.4 | 99.5 | 34.912 | 0.087 |
| 04 | 13.70 | 0.0298 | 0.3378 | 11.423 | 17.1 | 99.3 | 34.923 | 0.075 |
| **Mean age ± 2σ** | | n = 10 | MSWD = 0.92 | | 18.5 ± 2.0 | | **34.865** | **0.090** |
| **#215 TTV,** K8:15, san,J = 0.001437 ± 0.10%, D = 1.0093 ± 0.0019, nm-15,Lab# = 1767 | | | | | | | | |
| 10 | 14.77 | 0.2264 | 5.081 | 3.967 | 2.3 | 89.9 | 34.03 | 0.12 |
| 01 | 13.86 | 0.2284 | 1.918 | 1.539 | 2.2 | 96.0 | 34.09 | 0.12 |
| 05 | 13.84 | 0.2211 | 1.833 | 2.549 | 2.3 | 96.2 | 34.12 | 0.11 |
| 06 | 13.71 | 0.1836 | 1.283 | 4.111 | 2.8 | 97.3 | 34.185 | 0.091 |
| 02 | 14.77 | 0.2438 | 4.867 | 0.900 | 2.1 | 90.4 | 34.21 | 0.17 |
| 09 | 14.00 | 0.2153 | 2.083 | 1.822 | 2.4 | 95.7 | 34.33 | 0.12 |
| 08 | 14.37 | 0.1858 | 3.301 | 2.001 | 2.7 | 93.3 | 34.36 | 0.12 |
| 04 | 14.47 | 0.1811 | 3.611 | 3.504 | 2.8 | 92.7 | 34.37 | 0.11 |
| 07 | 13.84 | 0.1650 | 1.448 | 2.858 | 3.1 | 97.0 | 34.39 | 0.10 |
| 03 | 14.32 | 0.2057 | 2.962 | 1.355 | 2.5 | 94.0 | 34.49 | 0.13 |
| **Mean age ± 2σ** | | n = 10 | MSWD = 1.64 | | 2.5 ± 0.6 | | **34.26** | **0.12** |

*Note*: Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions. Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties. Mean age is weighted mean age of Taylor (1982). Mean age error is weighted error of the mean (Taylor, 1982), multiplied by the root of the MSWD where MSWD>1, and also incorporates uncertainty in J factors and irradiation correction uncertainties. Decay constants and isotopic abundances after Steiger and Jäger (1977). # symbol preceding sample ID denotes analyses excluded from mean age calculations. Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.02 Ma. Decay Constant (LambdaK (total)) = 5.543e – 10/a.
Correction factors (L#135-1808):
$(^{39}Ar/^{37}Ar)Ca$ = 0.00067 ± 4e-06
$(^{36}Ar/^{37}Ar)Ca$ = 0.00026 ± 2e-06
$(^{38}Ar/^{39}Ar)K$ = 0.01077
$(^{40}Ar/^{39}Ar)K$ = 0.032 ± 0.001
Correction factors (L# 2004-2015):
$(^{39}Ar/^{37}Ar)Ca$ = 7e-08 ± 0
$(^{36}Ar/^{37}Ar)Ca$ = 2.6e-08 ± 0
$(^{38}Ar/^{39}Ar)K$ = 0.01077
$(^{40}Ar/^{39}Ar)K$ = 0.019 ± 0.001

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