REGIONAL NEOTECTONIC ANALYSIS

OF THE

SONORAN DESERT

by

Bruce A. Schell and Kenneth L. Wilson

with contributions by

Gary E. Christenson and Steve L. Scott

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INTRODUCTION

The Sonoran neotectonic province comprises southeastern California, southwestern Arizona, and northwestern Mexico. This province occupies the area south of the Great Basin physiographic province between the Mojave Desert-Salton Trough-Gulf of California physiographic provinces on the west, and the Colorado-Sierra Madre Occidental plateaus on the east (Plates 1 and 2). The Sonoran neotectonic province extends southerly, beyond the limits of the map area, to the Guaymas area in Sonora, Mexico.

The term neotectonic refers to tectonic processes which are currently in action as opposed to paleotectonic which refers to tectonic processes which occurred under a previous tectonic regime. The time span over which neotectonic processes have been in action varies between tectonic provinces and is perhaps the single most important decision to be made during a neotectonic analysis. Such a decision can only be made by an iterative analysis of the younger paleotectonic processes as well as the neotectonic processes.

Boundaries between tectonic provinces are commonly very irregular and generally impossible to delineate on maps by a single line. Most of the boundary areas on Plate 1 are shown as zones of transition. The width of these transition zones represents the uncertainty in the location of the boundary which can be due to either lack of data or to transitional tectonic conditions. Where provinces are distinguished by an abrupt change in characteristics, such as across a well developed fault, the transition zone can be narrow; where tectonic conditions change more gradually, the transition zone is wide. It is important to note, however, that narrow transition zones do not necessarily imply more intense tectonic activity; if tectonic activity were intense in a narrow zone between two provinces, it probably indicates special tectonic conditions which are more appropriately shown as a discrete tectonic province or zone.

Analysis of regional geologic data reveals that the Sonoran province had a paleotectonic history similar in time and mode of deformation to the larger Basin and Range physiographic province which includes the Cenozoic block-faulted terrains of Nevada, western Utah, eastern California, Arizona, New Mexico, and northern Mexico (see Eardley, 1962; Gilluly, 1963; Hamilton and Myers, 1966). However, the geomorphology, distribution of young faults, and seismicity characteristics suggest a fundamental difference between the neotectonics of the Sonoran Desert and adjacent block-faulted terrains (Fenneman, 1931; Lobeck, 1939; Eardley, 1962; Lustig, 1969). The difference is characterized by a marked decrease in rate and amount of tectonic deformation in the Sonoran province so that now the province can be considered, nearly tectonically inactive (Arizona Nuclear Power Project, 1974; Howard and others, 1978). One of the prime objectives of our study was to determine the period of time when this tectonic divergence occurred. Based on the data analyzed, this change occurred between 4 and 8 million years ago (m.y.a.).

The data used in our analysis consisted of existing geologic information from published data and unpublished non-proprietary university and private-company reports. Where existing data were scarce or lacking, some limited aerial photograph and satellite imagery interpretation with limited field checking was performed.

DESCRIPTION OF ACCOMPANYING MAPS, DATA, AND METHODS OF ANALYSIS

General

The results of the neotectonic analysis of the Sonoran Desert area are presented on two map sheets. Plate 1 shows the neotectonic faults and volcanic outcrops of the Sonoran neotectonic province and adjacent areas. Plate 2 presents supporting tectonic data, sources of information, and reliability of data. Figure 1 (Plate 2) indicates tectonic activity based on analysis of geomorphology. Figures 2 through 4 (Plate 2) provide information on sources and the reliability of the data plotted on Plate 1. Figure 5 (Plate 2) is a diagram of present-day stress in the southwestern United States and the interaction between the Sonoran neotectonic province and its surrounding neotectonic provinces.

The abundance of young faults and young volcanic flows in the area surrounding the Sonoran neotectonic province (Plate 1) indicates greater neotectonic activity in these surrounding areas and is the primary purpose for showing portions of these neotectonic provinces. A detailed discussion of the characteristics of the surrounding provinces, however, is beyond the scope of this study.

Faults

There are only a few short faults or groups of young faults within the Sonoran neotectonic province (Plate 1). Several short faults within the province's transition zones (Chuckwalla, Needles, Chemehuevi) also might be related to neotectonic processes typical of the Sonoran province, whereas others (for example, McCullough Mountains, New York Mountains, Bristol Mountains) probably are not because their characteristics appear more similar to faults in adjacent provinces.

The data for age of most recent movement on the faults are summarized on Table 1. For the most part, these ages are based on Quaternary alluvial chronologies developed from correlations of geomorphically similar units (similarities are degree of dissection, desert pavement and varnish formation, topograpic position, and soil profile development) with potassium-argon, carbon 14, uranium-thorium, and amino acid dates, and paleomagnetic correlations. These chronologies have been developed in the southeastern Mojave Desert and northwestern Sonoran Desert largely by nuclear power plant investigations as reported in Early Site Review Reports and Preliminary Safety Analysis Reports (for example, Arizona Nuclear Power Project, 1974; Fugro, 1978; San Diego Gas and Electric Company, 1976; Southern California Edison Company, 1974; Woodward-McNeill and Associates, 1974). Many of these relationships are summarized in text by Shlemon (1980) and utilized in mapping such as by Carr and others (1980).

Figure 2 on Plate 2 shows the sources of data used to compile fault information. In Figure 3 (Plate 2), the data have been divided into several categories indicating reliability. The reliability indices are not necessarily indicative of the quality of the source data, but are a measure of our confidence in the applicability of information we were able to extract from the original data. We generally have more confidence in detailed maps (1:24,000 to 1:62,500) than in reconnaissance maps but we recognize that many detailed maps have very little information on Quaternary deposits or were done without the benefit of reliable age data.

The Pinacate faults are randomly oriented faults cutting basalts as young as late Pleistocene in the Pinacate lava field (Plate 1). Because of their random orientation, short length, and their lack of continuity into the Quaternary sedimentary deposits surrounding the basalts, they are believed to be associated with extrusion of the volcanics and (or) post-extrusion cooling. Therefore, they are probably representative of processes only within the volcanic field rather than of the province as a whole.

The Rio Sonoyta faults were reported by Merriam (1972) as cutting Quaternary alluvium along the banks of the Rio Sonoyta just south of the United States-Mexico border.

The Lost Trigo fault near Cibola in Yuma County, Arizona is within lower Pleistocene or upper Pliocene Colorado River terrace deposits. The fault is exposed only in the banks of drainage channels and does not displace the surface or middle Pleistocene (>500,000 years) alluvial deposits (San Diego Gas and Electric Company, 1976).

The Blythe graben has 3-m-high scarps in the alluvial fan deposits along the southwest side of the Big Maria Mountains in Riverside County, California. The feature is 5.5 km long and 92 m wide. Trenches excavated across the graben (San Diego Gas and Electric Company, 1976; Miller and others, 1979) revealed a 3-m displacement of subsurface alluvial fan deposits dated by the uranium-thorium method at 31,000 and 61,000 years. The faults do not displace stream terraces which are geomorphologically similar to terraces in the Vidal area (about 50 km to the north) dated at 6,000 years by the uranium-thorium method (San Diego Gas and Electric Company, 1976).

The Chemehuevi Graben forms parallel scarps with up to 1 m of relief in alluvial-fan deposits along the western side of the Colorado River near Lake Havasu. The graben trends nearly north-south, is slightly arcuate, and about 5 km long and 250 m wide. A trench excavated across the graben revealed near-vertical 1-m offsets of subsurface alluvial strata estimated to be older than 10,000 yrs based on the stratigraphic relationship to relatively dated alluvial fan deposits at the surface (Southern California Edison Company, 1974).

The Needles Graben displaces alluvial fans along the western side of the Black Mountains, Mohave County, Arizona, forming a topographic depression with up to 3 m of vertical relief. The graben trends northwesterly, roughly parallel to the trend of the Black Mountains. At the surface, the graben is about 5 km long and about 1,250 m wide. The faults bounding the graben displace intermediate-level alluvial-fan deposits which, based on degree of geomorphic development, are between 30,000 and 100,000 years old (Purcell and Miller, 1980).

The Chuckwalla Mountains fault lies along the southwest side of the Chuckwalla Mountains in Riverside County, California. Trenching of several aerial-photograph lineaments demonstrated that only one of them was fault related. This fault is about 3 km long and juxtaposes indurated fan deposits, which are probably greater than 500,000 years old (possibly Tertiary), against finer grained younger alluvium (San Diego Gas and Electric Company,1976). Younger fan surfaces overlying the fault appear to be undisturbed, but the relations are not definitive. The data do not allow a more refined estimate of time of last movement other than between late Tertiary and early Quaternary.

The Sand Tank fault is along the northwestern margin of the Sand Tank Mountains southeast of Gila Bend, Arizona. The fault has a sigmoidal trace for a distance of a little more than 3 km. The height of the scarp reaches a maximum of about 2 m, apparently the result of normal displacement with the northwest block down. The scarp is in intermediate-level alluvial fans probably of Pleistocene age. Geomorphic evidence suggests that the fault's last movement was in the late Pleistocene. The fault has not been trenched thus there is no subsurface information on the amount or number of displacements. The fault scarp morphology, however, suggests that this scarp is the result of one movement.

A group of short faults (300 to 400 m and 1.5 km long) have been mapped in the Mopah Range-Whipple Mountains area in San Bernardino County, California (Carr and others, 1980). These faults are seen primarily in the sides of drainage channels and have no prominent surface scarps (personal commun., D.D. Dickey, 1981). The faults displace old alluvial deposits of Pliocene and possibly early Pleistocene age. It is uncertain whether these faults formed under the present tectonic regime or whether they are related to late stage Basin and Range tectonism. The lack of surface relief or scarps suggests a Pliocene age of the last movement as indicated by Carr and others (1980).

Northeast-trending short faults in the McCullough Mountains-Crescent Peak area displace basin-fill deposits of Pleistocene and Pliocene age (possibly as old as the Muddy Creek Formation) (Bingler and Bonham, 1973). Two northwest-trending faults displace similar basin-fill units in the adjacent Highland Range. The nature of these faults as extensions into older alluvium from Precambrian and Tertiary rocks is not typical of neotectonic faults in this region, therefore the inclusion of these faults with Sonoran neotectonic features is doubtful.

Jennings (1975) shows a 4-km-long, northeast trending Quaternary fault along the margin between Ivanpah Valley and the New York Mountains. This fault is parallel to the strong alignment of the Kelso-Ivanpah-Eldorado trough which trends northeasterly from the Mojave province to Las Vegas Valley. This trough is transverse to the regional structural grain in this area and coincides with an apparent discontinuity in Tertiary volcanic rocks. This discontinuity is a primary reason for placing the Sonoran province boundary here. The location and the similarity of the fault trend to the trend of the trough suggests that the fault is peculiar to the trough and not typical of neotectonic processes within the Sonoran province.

Three short northwesterly trending faults in the Bristol Mountains are shown on the Needles (Bishop, 1963) and Kingman (Healey, 1970) geologic maps as displacing Plio-Pleistocene and Pleistocene non-marine deposits. The northwestern-most fault is shown as Quaternary by Jennings (1975). This area is at the junction of the Mojave, California Basin and Range, and Sonoran provinces where the distinction between provinces is not easily made. These faults are concordant with the local northwesterly structural fabric which is characteristic of the Mojave Province and thus they may be related to Mojave province tectonics.

Volcanic Rocks

Published state and county geologic maps (for example, Wilson and others, 1969) covering the Sonoran neotectonic province have an abundance of basaltic volcanic rocks shown as Quaternary and Quaternary-Tertiary (Pliocene and Pleistocene) age. All volcanic age dates determined since publication of these maps were compiled (Appendix A) and show that most previous age estimates are incorrect. By comparing and correlating undated units to dated units based on composition, relative stratigraphic position, geomorphic expression, and degree of deformation we assigned new age estimates to all undated units. This analysis resulted in the vast majority of previously classified Quaternary or Quaternary-Tertiary volcanic rocks being assigned a Miocene or older age (pre-Sonoran regime). Plate 1 shows the location and suspected age only of volcanic units having a known or estimated age within the approximate period of Sonoran neotectonics. The Appendix lists all of the ages used as the basis for these age correlations and Figure 4 (Plate 2) indicates the reliability and extent of available data.

Tectonic Geomorphology

Figure 1 of Plate 2 presents information on the tectonic activity of the Sonoran province based on analysis of the geomorphology of mountain fronts and river terraces along throughflowing drainages. Figure 1A (Plate 2) shows the sources of the data.

Tectonic geomorphology deals with the impact of local, tectonic, base-level fall on the processes and morphology of fluvial systems along mountain fronts. Local base-level processes include stream-channel downcutting in the mountains and erosion or deposition on the piedmont adjacent to the mountain front. These three processes are affected by relative uplift of the mountain front. The erosion, deposition, and uplift processes are closely related and are responsible for formation of distinctive landforms which are diagnostic of the relative degree of tectonic activity along the mountain fronts. For example, tectonically active mountain fronts, when compared to inactive mountain fronts of similar relief, climate, and rock type, have more convex ridgecrests, steeper slopes at the base of the mountain, narrower and steeper canyons in the mountains, less sinuous mountain fronts, thicker alluvial deposits next to the mountains, and minimal soil-profile development on the piedmont (Bull, 1973).

The tectonic geomorphology method for assessing degree of tectonic activity has been widely used in the Sonoran neotectonic province by nuclear power plant siting investigations near Blythe and Vidal Junction, California and Yuma, Arizona (Bull, 1974a, 1974b, 1976; Tucker, 1980). Other studies and detailed descriptions of the method are described by Bull (1977) and Bull and McFadden (1977). Figure 1B (Plate 2) denotes the areas covered by tectonic geomorphology studies within the Sonoran Desert region.

The incorporation of absolute age information with the relative ages provided by the tectonic geomorphology method allows some age inferences to be placed on the tectonic activity. In addition to the K-Ar dates on volcanics, age dates in the

Sonoran province consist of Th^{230}/U^{234} dates on soil carbonates (Woodward-McNeill and Associates, 1974; San Diego Gas and Electric Company, 1976), C^{14} dates on carbon rich materials (Metzger and others, 1973), and amino acid, magnetostratigraphy, and archaeological dates (San Diego Gas and Electric Company, 1976) (see Appendix A, Table A-2). The correlation of the deposits from which these dates were obtained to other similar deposits throughout the province was based on similarity of geomorphic development, topographic position, and stratigraphic position.

The tectonic geomorphology analysis for the Sonoran neotectonic province resulted in three classes of mountain fronts (Figure 1A, Plate 2). Class 1 mountain fronts occur in highly active tectonic areas generally characterized by active folding or faulting during the Holocene as well as the Pleistocene. Class 2 mountain fronts show evidence of activity during the Pleistocene but not the Holocene. Class 3 mountain fronts have been inactive throughout the Quaternary and perhaps part of the Pliocene (Bull, 1977).

The mountain fronts within the Sonoran neotectonic province are almost exclusively Class 3 which indicates a lack of tectonic activity in the province throughout Quaternary time. In contrast, the Mojave neotectonic province has several Class 2 and Class 1 mountain fronts (Figure 1A, Plate 2) indicative of a higher degree of tectonic activity during the Quaternary. The general aspect of the Sonoran neotectonic province is one of a block-faulted terrain that has been tectonically inactive for a long period of time with the mountains being slowly eroded away. This is supported by comparison of gravity and aeromagnetic maps (see West and Sumner, 1973; Sauck and Sumner, 1970) to geologic maps which indicate that basins are separated from the mountains by broad pediments, suggesting long-term erosion without renewed uplift.

Figure 1A (Plate 2) also depicts the geomorphology, height above the modern channel, and age of stream terraces in the Sonoran neotectonic province. Terrace profiles along the through-flowing streams in the Sonoran neotectonic province indicate very little tectonic disturbance during the late Pliocene and Pleistocene. A terrace consistently about 12 m above the level of the Gila River and overlain by 2 to 4 m.y.-old Sentinel-Arlington basalts indicates a lack of strong tectonic warping or fault rupture since that time in the central portion of the Sonoran neotectonic province. Along the northeastern edge of the province, however, terraces along the Aqua Fria, New, Salt, upper Gila, and Queen rivers diverge upstream, indicating uplift in the adjacent Arizona Mountains province (Péwé, 1978). In the Phoenix Basin, near the northeastern boundary of the Sonoran province, terraces are buried suggesting subsidence in the basin (Cooley, 1977; Péwé, 1978). However, no fault breaks have been reported in any of these terraces indicating that the subsidence is of a regional nature possibly due to gentle tectonic warping or to compaction and consolidation of the thousands of meters of basin fill.

Terraces along the Colorado River indicate tectonic stability within the western portion of the Sonoran neotectonic province, but are only about 80,000 years old (San Diego Gas and Electric Company, 1976). This time span is too short to be representative of the entire neotectonic stress regime which is several million years long. The Bouse Formation provides a longer record of elevation changes in the Colorado River area dating from about latest Miocene time. A profile (Luchitta, 1979) connnecting the highest erosional remnants of the formation shows only broad, rather uniform uplift except for two points; one point is in the Yuma area corresponding to the boundary between the Salton Trough-Gulf of California province and the Sonoran province, and the other in the Needles-Whipple Mountains area corresponding to the boundary between the Sonoran and Arizona Mountains provinces.

The inflection corresponding to the boundary between the Sonoran province and the Salton Trough-Gulf of California province is most likely due to relative subsidence across the numerous faults within the Salton Trough-Gulf of California province. The area of the profile inflection at the boundary between the Sonoran province and Arizona Mountains province is also a region of rather abrupt change in the geomorphology. The basins and ranges south of the Whipple Mountains are typical of the Sonoran province in that they are generally randomly oriented, have broad pediments, irregular mountain fronts, external drainage, and the area of the basins is about five times greater than that of the mountains. The area north of the inflection is more typical of the Great Basin in that basins and ranges have preferred northerly trends, mountain fronts are linear with only minor pediments, drainage is internal, and the ranges and valleys occupy about equal surface area. The less mature geomorphic characteristics north of the inflection indicate younger tectonic activity in the Arizona Mountain neotectonic province.

Regional Stresses

Figure 5 (Plate 2) shows the neotectonic stress regime of the southwestern U.S. The faults are generalized from King (1969) and the neotectonic province boundaries are modified from Schell (1978) and Schell and Hileman (1979). The stress indicators are primarily earthquake focal-mechanism solutions from the compilation of Smith and Lindh (1978) with contributions from Brumbaugh (1980) and King and others (1977). Where there are no earthquake focal mechanisms, limited in-situ stress measurements (for example, Sbar and others, 1979) and geologic indicators such as fault orientation, fault type, and trends of Quaternary volcanic vents are used. There are few indicators of neotectonic stress within the Sonoran province therefore the main emphasis is on the provinces coterminous to the Sonoran province. The data are highly generalized to simplify the illustration; a more complete compilation and discussion of stress data is given by Zoback and Zoback (1980).

The illustration shows that most of the southwestern United States is under a tensional stress regime. The similarities of stress indicators within some areas and lack of stress indicators within certain other areas suggests the existence of coherent crustal blocks (Colorado Plateau, Sierra Madre Occidental, Sonoran, and Sierra-Foothills-San Joaquin blocks) pulling away from the Interior Platform which is arbitrarily held fixed. The coherent blocks are separated by zones of extension where most of the stress is released by normal faulting (Rio Grande Rift, Mexican Basin and Range, Arizona Mountain, and Hurricane-Wasatch provinces). Even the Great Basin, which has experienced internal extensional deformation in Quaternary time, may be considered a coherent block of sorts because it suffers less internal deformation than the Hurricane-Wasatch and California Basin and Range provinces at its margins.

Complexities in the overall west-northwesterly extension occur along the northwestern edge of the Sonoran province in the Mojave province and the Western and Eastern Transverse Ranges provinces. The Transverse Ranges are under a compressional tectonic regime as indicated by abundant thrust and reverse-oblique faulting (see Dibblee, 1971; Jahns, 1973; Yerkes and Lee, 1979). The Mojave province exhibits shear deformation along numerous strike-slip faults bounded on the north by the northeasterly trending left-lateral Garlock fault and on the south by thrust and left-lateral faults in the Eastern Transverse Ranges.

DISCUSSION

General

The most obvious pattern illustrated by the accompanying maps is that there is little tectonic activity within the region designated as the Sonoran neotectonic province. Although the Sonoran province has not been studied in great detail, the barren nature of the Sonoran province as shown on Plate 1 is not completely a result of lack of data but largely a result of a very low rate of tectonic activity. Although the areas outside and immediately adjacent to the Sonoran province were subjected to slightly less scrutiny than the area inside the province, they show a relative abundance of young faulting, regional warping, and volcanic activity.

The basins and ranges in the Sonoran province were initiated sometime between 19 to 12 m.y.a., and most likely after 15 m.y.a. (Eberly and Stanley, 1978; Shafiqullah and others, 1980). Based on the subsurface relationships between basin-fill deposits, basalts, and geologic structure, the basins appear to have been well developed by about 10 m.y.a. and were essentially tectonically inactive by at least 4 to 5.5 m.y.a. when through flowing drainage was established (Arizona Nuclear Power Project, 1974; Luchitta, 1979). The waning of Basin and Range tectonics is bracketed by rocks in which faulting decreases with age. For example, compared to older volcanic rocks extruded during the Basin and Range disturbance, fault displacements in 8 to 10 m.y. old volcanic rocks are relatively minor, and there are no displacements in younger rocks such as the Sentinel-Arlington volcanic field (about 2 to 4 m.y. old) or its surrounding Pliocene playa deposits (Arizona Nuclear Power Project, 1974). The lack of volcanic rocks in the 4 to 8 m.y. age range further suggests tectonic stability during that interval. The only apparent feature in the Sonoran province younger than about 8 m.y. which might indicate significant tectonic activity is the Sentinel-Arlington volcanic field. The late Pleistocene Pinacate volcanic field which straddles the southwestern boundary of the province is believed to be associated with rifting in the Gulf of California and not typical of the Sonoran province.

Sentinel-Arlington Volcanic Field

Extrusion of the Sentinel-Arlington basalts occurred primarily during the Pliocene Epoch but their age is not well constrained. Shafiqullah and others (1980) postulated that the time interval during which the field was extruded, indicated by the radiometric age range (1.3 to 6.5 m.y.), is too long. Geomorphic evidence suggests that these volcanics were extruded during a relatively shorter time interval. The bulk of the radiometric age dates (80 percent) fall within the 2 to 4 m.y. range which seems to be more compatible with the length of time indicated by geomorphology.

The mechanics of the origin of the Sentinel-Arlington volcanic field is poorly understood and very speculative. The field is not related to a major young fault zone but it does occur along a northeast-southwest trending linear zone where geothermal gradients are higher than normal (see Hahman and others, 1978). Eberly and Stanley (1978) documented the existence of a pre-late Miocene (possibly Precambrian) NE-SW trending trough, the Gila Trough, below the modern course of the Gila River. This trough is transected by NW-SE trending grabens formed during the Miocene Basin and Range disturbance. It is possible that the intersections of the two ancient fault trends could provide the necessary zones of crustal weakness along which magmatic material could reach the earth's surface rapidly enough to maintain a basaltic composition. Similar modes of origin have been postulated for relatively young basalt flows in the Great Basin region (for example, Rowley and others, 1979).

Although the extrusion of the Sentinel-Arlington field, between 2 to 4 m.y.a., might be related to extensional tectonics, it seems unlikely, considering the long quiescent interval from 4 to 8 m.y.a., that the event is part of continuous Basin and Range tectonics. It seems more likely that extrusion of the volcanics may have been related to reactivation of a pre-Sonoran feature by crustal extension during rifting of the Baja Peninsula away from the Sonoran mainland. Further studies of the composition of the volcanics and comparison with other volcanics in the southwestern United States may shed additional light on this speculation.

Neotectonic Faults

The faults within the Sonoran neotectonic province (Table 1; Plate 1) are very short, widely spaced, generally geomorphically inconspicuous, characterized by small displacements, and randomly oriented. These characteristics indicate a very low level of tectonic activity which is consistent with the very low level of seismicity in the province. Therefore, the relatively high rates of tectonic activity in the provinces of the western United States surrounding the Sonoran province indicate that most crustal stress and strain is released within these surrounding provinces. However, it seems plausible that small amounts of this stress may be transmitted across the boundaries into the Sonoran province and may be responsible for a small amount of very infrequent faulting along ancient zones of weakness. Most of the faults are located near the edges of the province and are of tensional origin which is compatible with stresses in the surrounding provinces. Small movements on these faults could also be attributable to gravitational adjustments such as differential compaction of thick accumulations of basin sediments, or to local base level decline along the Colorado River or within local ground-water basins.

CONCLUSION

The data assessed in this study indicate the Sonoran neotectonic province to be a relatively coherent block which has been, with few exceptions, tectonically stable since the end of the Basin and Range disturbance. The change from the active Basin and Range tectonic regime to the present essentially inactive regime seems to have occurred over a period of several million years between less than 8 m.y.a. and more than 4 m.y.a. These dates bracket the interval during which the Sonoran province diverged tectonically from the surrounding provinces. Just prior to 8 m.y.a., plate motion geometry in the Gulf of California region underwent a major change (Larson, 1972) and the subsequent time interval between 8 to 4 m.y.a. was a time of major tectonic reorganization in the western United States. During this time the southern San Andreas transform fault system and faults associated with the system such as the Garlock and San Gabriel faults developed (Carter, 1971; Crowell, 1973; Terres and

Crowell, 1979), the fault blocks in the Great Basin acquired their present degree of development (Stewart, 1978), and volcanism ceased on the Columbia Plateau (McKee and Swanson, 1977).

By about 5 m.y.a. the southern triple junction of the Pacific spreading system was at the tip of Baja (Atwater, 1970) and volcanism accelerated in the Rio Grande rift (Chapin and Seager, 1975). By about 4 m.y.a. the Baja peninsula began to pull away from the Sonoran mainland (Larson, 1972). With the full development of rifting and transform faulting in the San Andreas-Gulf of California system, the Sonoran neotectonic stress field was in effect.

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TABLE 1

POSSIBLE NEOTECTONIC FAULTS IN THE SONORAN NEOTECTONIC PROVINCE AND SURROUNDING TRANSITION ZONES

FAULT NAME AND LOCATION	YOUNGEST STRATUM DISPLACED	OLDEST STRATUM NOT DISPLACED	PROBABLE AGE OF LAST MOVEMENT
RIO SONOYTA FAULTS, Sonora, Mexico	Quaternary alluvium	- -	late Quaternary
PINACATE FAULTS, Pinacate lava field, Sonora, Mexico	Upper Pleistocene basalt	Holocene or upper Pleistocene alluvium	late Pleistocene
LOST TRIGO FAULT, near Cibola, Yuma County, Arizona	lower Pleistocene or upper Pliocene terrace deposits	middle Pleistocene alluvium	early Pleistocene
BLYTHE GRABEN, northwest of Blythe, Riverside County, California	6,000 to 31,000 year-old alluvial fan deposits	-	late Pleistocene to early Holocene
CHEMEHUEVI GRABEN, West of Lake Havasu, San Bernardino County, California	10,000 year-old alluvium	-	early Pleistocene
NEEDLES GRABEN, northeast of Topock, Mohave County, Arizona	30,000 to 100,000 year-old alluvial fan deposits	-	late Pleistocene
CHUCKWALLA MTS., Riverside County, California	lower Quaternary (?) alluvium (>500,000 yrs.)		late Tertiary or early Quaternary
SAND TANK MTS., southeast of Gila Bend, Maricopa County, Arizona	upper Quaternary alluvial fan gravels	-	late Quaternary
NINETY SIX HILLS, Pinal County, Arizona	Quaternary alluvium	-	Quaternary
McCULLOUGH MTS., Clark County, Nevada	Pliocene or Pleistocene gravels	-	Pliocene or Pleistocene

TABLE 1 (Continued)

FAULT NAME AND LOCATION	YOUNGEST STRATUM DISPLACED	OLDEST STRATUM NOT DISPLACED	PROBABLE AGE OF LAST MOVEMENT
CRESCENT PEAK, Clark County, Nevada	Pliocene or Pleistocene gravels	-	Pliocene or Pleistocene
HIGHLAND RANGE, Clark County, Nevada	Pliocene or Pleistocene gravels	-	Pliocene or Pleistocene
NEW YORK MTS., San Bernardino County, California	Quaternary alluvium	-	Quaternary
BRISTOL MTS., San Bernardino County, California	Plio-Pleistocene or Pliocene alluvium	-	Quaternary
MOPAH RANGE, (four short faults) northwest of Vidal Junction, San Bernardino County, California	Holocene to Pliocene colluvium, largely lower Pleistocene and upper Pliocene	upper Pleistocene to upper Pliocene alluvium	late Pliocene or early Pleistocene
WHIPPLE MTS. PIEDMONT FAULTS, Several small faults north of Vidal Junction, San Bernardino County, California	upper Pleistocene to upper Pliocene alluvium, Miocene Osborne Wash Fanglomerate, and Holocene to Pliocene colluvium	Holocene and Pleistocene alluvium	late Pliocene or early Pleistocene

APPENDIX A

LIST OF AGE DATES

ABBREVIATIONS USED FOR DATING METHOD ON AGE-DATE LIST

KA	-	Potassium-Argon
KAWR	-	Potassium-Argon, whole rock
KAPLA	-	Potassium-Argon, plagioclase
KABIO	-	Potassium-Argon, biotite
KAMUS	-	Potassium-Argon, muscovite
KAFEL	-	Potassium-Argon, feldspar
KAKAER	-	Potassium-Argon, kaersutite
KACHIL	-	Potassium-Argon, chilled rock
KAHBN	-	Potassium-Argon, hornblende
KAGLA	-	Potassium-Argon, glass
KAANO	-	Potassium-Argon, anorthosite
F. TRACK	-	Fission Track
Pb	-	Lead-alpha particle
C^{14}	-	Carbon 14

APPENDIX A

TABLE A-1

AGES OF IGNEOUS ROCKS

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
1	Continental Granodiorite, AZ	110° 48.50' 31° 47.92'	1,360 ± 200	Pb	17 (1046)
2	Elephant Quartz Monzonite, AZ	110° 53.83' 31° 43.58'	190 ± 30	Pb	17,19 (876)
3	Alkali Granite, Sierrita Mtns, AZ	111° 11.50' 31° 54.00'	150 ± 20 55 ± 3	Pb KABIO	8 (T169)
4	White crystal tuff, intercalated with poorly consolidated clastics; age spurious, probably Oligocene or Miocene, AZ	114° 11.60' 32° 42.68'	78 ± 4.3	KABIO	21 (112)
5	Basalt, Reeves No. 1 Fuqua, 1050-1062 m depth; age spurious, probably Oligocene	112° 39.00' 33° 25.10'	72 ± 13.2	KABIO	21 (96)
6	Monzonite, Sacaton Mtn, AZ	111° 49.00' 32° 59.00'	71.7 ± 2	KAWR	2&21 (71-69)
7	Schist, Mule Mtns, CA	114° 48.00' 33° 31.10	69.6 + 2.6	KABIO	24 (RD-3)
8	Elephant Quartz Monzonite, AZ	110° 53.83' 31° 43.58'	69.0 + 2.9	KABIO	17,19 (876)
9	Granodiorite, Little Harquahala Mtns, AZ	113° 40.45' 33° 44.77'	69	KABIO	21 (94)
10	Granodiorite, Wickenburg Batholith, Vulture Mtns, AZ	112° 50.50' 33° 52.50'	68.4 ± 1.7	KABIO	40 (71-34)
11	Granite, Vulture Mtns, AZ	112° 50.80' 33° 56.80'	65.6 ± 1.4	KABIO	40 (75-55)
12	Granodiorite, Little Harquahala Mtns, AZ	113° 40.52' 33° 45.00'	65.0 ± 5.5	KABIO	13 (PED-3-68)
13	Hornblende Gneiss, Mesquite Mtn, AZ	114° 19.00' 33° 57.00'	63.8 ± 3.0		24 (RD-19)
14	Granodiorite, Wickenburg Batholityh, Vulture Mtns, AZ	112° 47.00' 33° 56.80'	62.9 ± 1.2	KABIO (Vermiculized)	40 (71-14)
15	Granitic Greater Granite Pass, Iron Mtns, CA	115° 13.00' 34° 04.00'	62.7 ± 0.6	KAWR	45 (C-603)
16	Granitic Center of Granite Pass, Iron Mtns, CA	115° 13.00' 34° 02.00'	61.8 ± 0.6	KAWR	45 (C-604)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
17	Granitic North side of Granite Pass, Iron Mtns, CA	115° 13.00' 34° 04.00'	60.5 ± 0.6	KAWR	45 (C-602)
18	Granite Gneiss, coarse grained; spurious date, Precambrian gneiss with Laramide recrystallization, AZ	114° 35.87' 32° 40.27'	59 ± 3.2	KABIO	21
19	Granitic South side of Granite Pass, Iron Mtns, CA	115° 13.0' 34° 02.0'	58.7 ± 0.6	KAWR	45 (C-605)
20	Granitic North side of Granite Pass, Iron Mtns, CA	115° 13.0' 34° 05.0'	58.7 ± 0.6 58.6 ± 0.6	KAWR KAWR	45 (C-601)
21	Los Cerritos Gneiss, 38 km SE of San Luis, Sonora, Mexico; spurious date, Precambrian gneiss with Laramide recrystallization		58.0 ± 3.1 57.0 ± 3.3	KABIO KABIO	21 (114)
22	Hornblende-Orthoclase Gneiss, Rawhide Mtns, AZ	113° 41.0' 34° 15.0'	57.4 ± 1.3	KAHBN	42
23	Augite-Hypersthene Andesite, CA	114° 52.0' 33° 26.0'	56.4 ± 1.6	KAPLA	10 (PV-34)
24	Continental Granodiorite, AZ	110° 48.50' 31° 47.92'	55.5 ± 2.4	KABIO	45 (1046)
25	Alkali Granite, Sierrita Mtns, AZ	111° 11.50' 31° 54.00'	55 ± 3 150 ± 20	KABIO Pb	8 (T169)
26	Biotite Schist, Rawhide Mtns, AZ	113° 41.00' 34° 15.00'	52.3 ± 1.4	KABIO	42
27	Basalt; G. D. Isabel No. 1, Maricopa Co, 588-610 m depth; age spurious probably Oligocene or Miocene, AZ	112° 15.20' 33° 39.30'	51 ± 3.3	KABIO	21
28	Crystal tuff (intercalated with lakebeds); age spurious, probably Oligocene or Miocene,	113° 41.27' 34° 11.47'	48 ± 2.8	KABIO	21 (87)
29	Basaltic Andesite; Sperry Gyroscope No. 1, 466-477 m depth; age spurious, probably Oligocene or Miocene	112° 05.85' 33° 41.03'	44 ± 5	KABIO	21
30	Basalt, AZ	113° 35.83' 34° 21.87'	43.3 ± 3.3	KAWR	25 (KA-1235)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
31	Andesite, AZ	113° 24.15' 34° 20.08'	41.5 ± 1.2	KABIO	25 (KA-1237)
32	Altered Ash-Flow Tuffs, Patsy Mine volcanics, Black Mtns, AZ	114° 36.05' 35° 46.62'	40.8 ± 1.6	KABIO	1 (46)
33	Basaltic Andesite, Drill hole, Higley Basin, 2720-2735 m depth, AZ	111° 41.3' 33° 17.0'	39.4 ± 0.9	KAWR	44 (74-130)
34	Rillito Andesite, North end of Tucson Mtns, AZ	111° 08.37' 32° 19.57'	38.5 ± 1.3	KABIO	4&21 (PED-9-63&19)
35	Granite Gneiss, Precambrian gneiss with Laramide recrystallization; AZ	114° 35.87' 32° 40.27'	38 ± 2.0	KABIO	21 (116)
36	Rhyolite Ash-Flow, Pantano Fm, AZ	110° 38.60' 31° 59.80'	36.7 ± 1.7	KASAN	16 (PED-13-62)
37	Augite-Hypersthene Andesite, Palo Verde Mtns, CA	114° 52.00' 33° 26.00'	36.4 ± 4	KAPLA	10 (F-3)
38	Palo Verde Mtns, CA	115° 05.00' 33° 27.00'	35.0 ± 3.0	KAPLA	10 (F-5)
39	Hornblende Rhyodacite plug, Palo Verde Mtns, CA	114° 48.00' 33° 18.00'	34.7 ± 1.3	KAPLA	10 (F-9)
40	Mica Schist (Pinal Schist); recrystallized Precambrian schist, AZ	110° 25.50' 32° 13.50'	33.8 ± 1.2	KABIO	33
41	Sanidine-rich Rhyolite, Salton Wash, CA	115° 42.00' 33° 31.00'	33.0 ± 1.0	KAPLA	10 (SW-1)
42	Hypersthene-Augite Dacite, Picacho area, southeastern CA	114° 37.08' 32° 58.50'	31.8 ± 3.2	KAPLA	9 (5-86)
43	Banded Gneiss, AZ	110° 55.07' 32° 20.10'	31.2 ± 0.9	KABIO	35 (PED-56-66)
44	Turkey Track Porphyry pillow lava in Hemet fanglomerate, AZ	111° 04.50' 31° 57.10'	30.7 ± 1.2	KAPLA	13 (RM-2-64a)
45	Pegmatite Dike in Gneissic Quartz Monzonite, Baboquivari Mts, AZ (northerly strike)	111° 35.60' 31° 35.00'	30.3 ± 0.6	KAMUS	44 (73-70)
46	Rhyolite Tuff, overlies Kinter Fm, north Gila Mtns, AZ	114° 28.30' 32° 48.90'	30.1 ± 1.0	KABIO	44 (65-04)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
47	Olivine Andesite, Palo Verde Mtns, CA	114° 52.00' 33° 22.00'	30.0 ± 3.0	KAWR	10 (F-8)
48	Leatherwood Quartz Diorite, AZ	110° 45.00' 32° 26.00'	29.6 ± 0.6	KABIO	14 (PED-1-68)
49	"A" Mtn Gray tuff, east side of Tucson Mtns, AZ	110° 59.37' 32° 12.53'	29.7 ± 0.9 29.7 ± 0.9	KASAN KASAN	4 (PED-76-63&21)
50	Tuff, Gila Bend Mtns, AZ	112° 47.00' 33° 12.00'	29.4 ± 0.6	KABIO	44 (73-25)
51	Basalt, AZ	113° 33.85' 33° 06.98'	29.3 ± 3.1	KAWRO	21 (UAKA-72-47)
52	Pantano Tuff, AZ	110° 38.10' 32° 01.40'	29.2 ± 0.9	KABIO	12 (PED-7-65)
53	Welded Tuff, Berry No 1 Federal, 1057-1072 m depth Avra Valley, AZ	111° 18.40' 32° 26.53'	29 ± 2.4	KAWR	21 (11)
54	Gillespie Basalt Flow, AZ	112° 47.00' 33° 12.00'	28.8 ± 0.5	KAWR	23 (G-11,73-25)
55	Diorite Dike, cuts metamorphic and granitic rocks in Harquahala Mtns (NW trend), AZ	113° 17.80' 33° 45.70'	28.6 ± 1.9	KAHBN	44 (HLa-2)
56	Augite-Olivine Andesite, CA	114° 52.00' 33° 23.00'	28.2 ± 3.9	KAPLA	10 (PV-21)
57	Basaltic Andesite, AZ	113° 29.68' 33° 16.72'	28 ± 4.2	KABIO	21 (102)
58	Fine Tuff, in Hemet Conglomerate, AZ	111° 06.82' 31° 55.82'	27.9 ± 2.6	KABIO	16 (RM-1-64)
59	Petroglyph Hills Andesite, AZ	111° 24.70' 32° 23.12'	27.9 ± 1.4	KABIO	34&21 (PED-1-63&10)
60	Altered Ash-Flow Tuff, Patsy Mine volcanics, Black Mtns, AZ	114° 36.05' 35° 46.62'	27.9 ± 1.1	KABIO	1 (45)
61	Biotite-Sanidine Rhyolite Ignimbrite, Palo Verde Mtns, AZ	114° 53.00' 33° 23.00'	27.9 ± 0.9	KABIO	10 (F-1)
62	Granite, north of Tortolita Mts near Brady Wash, AZ	111° 08.20' 32° 43.60'	27.7 ± 0.7	KABIO	44 (63-36)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
64	Basaltic Andesite, Gillespie flow, Gila Bend Mtns, AZ	112° 46.00' 33° 12.00'	27.41 ± 0.66	KAWR	23,44 (G-6,73-26)
65	Quartz Monzonite Gneiss, AZ	111° 05.00' 32° 28.00'	27.3 ± 0.9	KABIO	35 (PED-20-62)
66	Sanidine-rich Rhyolite Dome, CA	115° 42.00' 33° 31.00'	27.3 ± 0.4	KASAN	10 (SW-1-3B)
67	Granodiorite, AZ	110° 27.00' 32° 12.00'	27.3 ± 1.1	KABIO	33
68	Basaltic Andesite, AZ	110° 16.40' 32° 17.07'	27.29 ± 0.57	KAWR	41 (UAKA-78-41)
69	Volcanic, crest of Mopah Range, CA	114° 45.00' 34° 19.00'	27.1	KAWR	45 (M-1)
70	Welded Rhyolitic Tuff, upper part of Sil Murk Fm, AZ	112° 47.80' 33° 04.87'	27 ± 3.8	KAWR	21 (99)
71	Basalt, Palo Verde Mtns, AZ	114° 53.00' 33° 28.00'	26.9 ± 1.4	KAWR	24 (RD-10)
72	Banded Gneiss, light band, AZ	110° 41.07' 32° 20.05'	26.8 ± 0.8	KAORT	35 (PED-18-626)
73	Sullivan Buttes Latite, NE side of Chino Valley, AZ	112° 25.32' 34° 51.13'	26.7 ± 1.1	KAHBN	31 (PA-4)
74	Cerro Prieto Basalt, Cerro Prieto, Samaniego Hills, Pinal-Pima Co line, AZ	111° 26.00' 32° 31.00'	26.6 ± 0.8	KAWR	20&21 (RLE-27-68&8)
75	Rhyolite and Trachyte, AZ	112° 14.53' 33° 58.08'	26.48 ± 0.56	KAWR	41 (UAKA-78-39)
76	Crystal Vitric Tuff, top of 61 m section of volcanic rocks overlying basement complex; tuff overlain by conglomerate, AZ	114° 31.67' 32° 28.88'	26.3 ± 1.6	KAWR	12 (PED-4-65)
77	Turkey-track Prophyry, overlies Mineta Fm, AZ	110° 29.83' 32° 20.25'	26.3 ± 2.4	KAPLA	15 (PED-3-69)
78	Rhyodacite Vitrophyre, Grosvenor Hills volcanics	110° 53.17' 31° 34.08'	26.2 ± 1.9	KAPLA	17 (710)
79	Rhyolite Ignimbrite, N of Yuma, AZ	114° 31.20' 32° 55.25'	26.2 ± 1.6	KASAN	38 (COL2-35:1A)
80	Granite Stock, Chocolate Mtns, CA	115° 40.00' 33° 30.00'	26.0 ± 0.2	KASAN	10 (CG-B)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
81	Rhyolite, Vulture Mtns, AZ	112° 48.70' 33° 53.80'	26.0 $\pm$ 0.6	KABIO	40 (75-64)
82	Rhyolite Vitrophyre, Box Canyon dike swarm	110° 48.08' 31° 45.50'	25.9 $\pm$ 1.3	KASAN	18 (899)
83	Rhyodacite Tuff, N of Yuma, AZ	114° 32.87' 32° 56.62'	25.9 $\pm$ 0.9	KABIO	38 (COL2-7L41A)
84	Basaltic Andesite, Chocolate Mtns, CA, probably older than Kinter Fm	114° 31.65' 32° 49.88'	25.8 $\pm$ 1.6	KAWR	44 (68-09)
85	"A" Mtn Gray Tuff, east side of Tucson Mtns, AZ	110° 59.37' 32° 12.53'	25.8 $\pm$ 0.9	KASAN	41&42 (PED-76-63&21)
86	Pyroxene-Olivine Andesite CA	115° 16.00' 33° 31.00'	25.7 $\pm$ 1.3	KAPLA	10 (AP-2)
87	Silicic Ash, Jim Thomas Wash, San Manuel Fm, Crozier Peak Quad, AZ	110° 56.71' 32° 58.75'	25.6 $\pm$ 0.6	KAHBN	41 (76-133)
88	Biotite-Sandine Rhyolite Welded Ignimbrite, Palo Verde Mtns, CA	114° 52.00' 33° 22.00'	25.6 $\pm$ 1.0	KA	10 (F-7)
89	Pyroxene Andesite, CA	115° 05.00' 33° 27.00'	25.6 $\pm$ 4.2	KAPLA	10 (LC-4)
90	Quartz Latite, AZ	110° 32.10' 32° 51.57'	25.6	KABIO	28
91	Porphyritic Two-Pyroxene Andesite, CA	115° 05.00' 33° 28.00'	25.5 $\pm$ 0.2	KAPLA	10 (LC-15)
92	Quartz Latite, A2	110° 32.10' 32° 51.57'	25.4	KASAN	28
93	Banded Gneiss, Light band, AZ	110° 41.07' 32° 20.05'	25.4 $\pm$ 1.0	KAMUS	35 (PED-18-62L)
94	Hornblende Andesite, Chocolate Mtns, CA	114° 33.20' 32° 56.93'	25.4 $\pm$ 1.5	KAHBN	44 (67-01)
95	Gneissic Quartz Monzonite, Harcuvar Mtns, AZ	113° 34.00' 33° 59.00'	25.33 $\pm$ 0.54	KABIO	44 (75-107)
96	Safford Tuff, north end of Tucson Mtns, AZ	111° 08.35' 32° 19.72'	25.2 $\pm$ 1.4	KABIO	4&21 (PED-10-63&18)
97	Perlite, Palo Verde Mtns, CA	114° 52.00' 33° 24.00'	25.2 $\pm$ 2.5	KAPLA	10 (F-2)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
98	Banded Gneiss light band, AZ	110° 41.07' 32° 20.05'	25.1 ± 1.0	KABIO	35 (PED-18-62L)
99	Basaltic Andesite, N of Yuma, AZ	114° 31.65' 32° 49.97'	25.1 ± 1.6	KAWR	15 (PED-9-68)
100	Capping Pyroxene Andesite, N of Yuma, AZ	114° 31.65' 32° 49.88'	25.1 ± 1.6	KAWR	38 (HC2-15:35B)
101	Rhyolite, AZ	110° 27.28' 32° 17.10'	25.10± 0.55	KAWR	41 (UAKA 78-33)
102	Quartz Latite, Silver Bell Mtns, AZ	111° 29.50' 32° 26.60'	25.0 ± 2.0	KABIO	34&21 (RM-4-63&9)
103	Dacite, Palo Verde Mtns, CA	114° 53.00' 33° 24.00'	25.0 ± 1.1	KAGLA	24 (RD-8)
104	Basalt (Ajo Volcanics), overlies Locomotive Fanglomerate, AZ	112° 52.22' 32° 19.62'	25 ± 2.7	KAWR	21 (108)
105	Quartz Diorite Gneiss, 3101-3102 m depth, AZ	111° 29.73' 32° 45.70'	25 ± 1.4 (reduced age) (Rb-Sr indicates 1275 & 1540 my)	KABIO	43 (73-410,74-87)
106	Welded Rhyolite Tuff, AZ	114° 37.63' 33° 15.08'	25 ± 1.7	KAWA	21 (120)
107	Granite, Goodwin Canyon Stock, Pinale Mtns, AZ	110° 15.00' 32° 57.00'	24.95± 0.69	KAWR	39&21 (JKP-49-66&23)
108	Basaltic Andesite, Black Mtn, overlies San Xavier Conglomerate, Del Bac Hills, south of Tucson Mtns, AZ	T16 R12 S1	24.8 ± 0.7	KAWR	39&21 (JKP-49-66&23)
109	Hornblende Andesite, N of Yuma, AZ	114° 33.20' 32° 56.93'	24.7 ± 2.1	KAHBN	13 (PED-1-6-75)
110	Andesite F, N of Yuma, AZ	114° 33.20' 32° 56.93'	24.7 ± 2.1	KAHBN	38 (COL1-7:38A)
111	Basalt, north of Trout Creek, AZ	113° 28.62' 35° 01.23'	24.7 ± 3.5	KAWR	46
112	Rhyolite Tuff, AZ	110° 32.80' 32° 54.87'	24.6 ± 1	KABIO	27
113	Safford Peak Dacite, north end of Tucson Mtns, AZ	111° 08.92' 32° 20.73'	24.5 ± 0.9	KABIO	4&21 (PED-1-64&17)

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114	Augite-Hypersthene Andesite, AZ	111° 52.00' 33° 26.00'	24.5 ± 1.7	KAPLA	10 (PV-33)
115	Tuff, AZ	111° 29.90' 32° 51.50'	24.4 ± 1	KABIO	28
116	Turkey-Track Porphyry, upper part of Pantano Fm, AZ	Unknown	24.4 ± 2.6	KABIO	22
117	Northstar Granodiorite, stock associated with northerly-trending dikes in Precambrian basement, AZ	111° 21.30' 32° 48.10'	24.35 ± 0.73	KABIO	44 (73-64)
118	Rhyolite Tuff, San Manuel Fm, Tortilla Mtns, Crozier Peak Quad, AZ	110° 56.75' 32° 58.75'	24.1 ± 0.7	KASAN	29
119	Rhyolite, Palo Verde Mtns, CA	114° 52.00' 33° 24.00'	24.1 ± 1.0	KABIO	24 (RD-9)
120	Andesite, AZ	111° 04.25' 31° 56.75'	24	KABIO	33
121	Welded Rhyolitic Tuff, AZ	114° 05.63' 33° 49.87'	24 ± 1.6	KABIO	21 (91)
122	Plutonic Rock, Chocolate Mtns, CA	115° 34.00' 33° 29.00'	23.9 ± 0.7	KABIO	10 (CAMG1-68)
123	Rhyolite Ignimbrite, CA	115° 24.00' 33° 28.00'	23.7 ± 0.3	KASAN	10 (CG-642)
124	Latite Ash-Flow Tuff, Eagle Tail Mtns, AZ	113° 28.33' 33° 29.05'	23.7 ± 0.7	KABIO	44 (72-73)
125	Basalt, Exxon well 14-1, 180-190 m depth, unlithified sediments, AZ	113° 21.00' 33° 08.00'	23.7 ± 0.6	KAWR	44 (72-117)
126	Rhyolite Flow, AZ	113° 13.62' 33° 13.40'	23.64 ± 0.51	KAWR	41 (78-47)
127	Rhyolite Ash-Flow, 40-50° NE dip, Kofa Mtns, AZ	113° 57.20' 33° 27.97'	23.6 ± 0.62	KABIO	44 (73-18)
128	Basaltic Andesite, Martinez Hill, Del Bac Hills, south of Tucson Mtns, AZ	T15 R13 S23	23.5 ± 0.7	KAWR	39&21 (JKP-10-67&22)
129	Basaltic Andesite, Roskruge Mtns, AZ	111° 19.83' 32° 07.48'	23.5 ± 1.4	KAWR	3&21 (MB-12-64&15)
130	Quartz Monzonite, AZ	110° 28.00' 32° 07.00'	23.5 ± 0.9	KABIO	33

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131	Porphyritic Augite-Hypersthene, Hornblende, Quartz Latite, CA	115° 25.00' 33° 28.00'	23.5 ± 1.1	KAPLA	10 (CG-57)
132	Basaltic Andesite, CA	111° 15.00' 31° 43.00'	23.4 ± 0.9	KAWR	14 (JKP-2-68)
133	Sullivan Buttes Latite, NE side of Chino Valley, AZ	112° 15.47' 34° 25.38'	23.4 ± 1.0	KABIO	31 (PA5)
134	Andesitic Basalt, Exxon State (32) No 1, 2420-2426 m depth, AZ	110° 48.00' 31° 56.00'	23.4 ± 0.6	KAWR	21 (UAKA-72-76)
135	Silica Ash, Jim Thomas Wash, Manuel Fm, Crozier Peak Quad, AZ	110° 56.71' 32° 58.75'	23.4 ± 0.6	KAHBN	41 (76-133)
136	Metavolcanic, Mesquite Mtn, AZ	114° 19.00' 33° 59.00'	23.3 ± 1.0		24 (RD-14)
137	Rhyolite Ignimbrite, CA	115° 24.00 33° 29.00'	23.3 ± 0.7	KABIO	10 (CG-55)
138	Basaltic Andesite, Dobbs Buttes, AZ	111° 24.55' 32° 04.05'	23.3 ± 0.7	KAWR	3&21 (MB-6-64&16)
139	Basalt, Cave Creek, AZ	111° 57.33' 33° 53.50'	23.3 ± 2.7	KAWR	44 (70-05)
140	Rhyolite Ignimbrite, Palo Verde Mtns, CA	114° 48.00' 33° 18.00'	23.1 ± 0.9	KAHBN	10 (F-10)
141	Porphyritic Granite, Chocolate Mtns, CA	115° 21.00' 33° 19.00'	23.1 ± 0.7	KABIO	10 (CMG1-36)
142	Basalt, Antelope Peak, AZ	112° 10.50' 32° 47.85'	23 ± 5.2	KAWR	21 (1)
143	Basalt, G. D. Isabel No. 1, No. 1, 288-325 m depth Maricopa Co, AZ	112° 15.20' 33° 39.30'	23 ± 7.7	KAWR	21 (60)
144	Rhyolitic Tuff, intercalated with underlying lacustrine sediments, AZ	113° 26.85' 33° 16.38'	23 ± 1.6	KABIO	21 (101)
145	Rhyolitic Tuff, intercalated with red clastics, AZ	114° 06.32' 32° 47.28'	23 ± 2.7	KAWR	21 (110)
146	Altered Ash-Flow Tuff, Patsy Mine Volcanics, Black Mtns, AZ	114° 36.05' 35° 46.62'	22.8 ± 0.9	KASAN	1 (44)

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147	Granite, Black Rock and Goat Cyns, Santa Theresa Mtns, AZ	110° 16.10 32° 54.80'	22.8 ± 0.55	KABIO	44 (75-21)
148	Andesite, AZ	110° 31.26' 32° 49.74'	22.78± 0.48	KAWR	41 (76-96)
149	Hornblende Rhyodacite,	114° 38.00' 33° 01.17'	22.7 ± 5.9	KAPLA	9 (3-26)
150	Trachyte, drill hole, Paradise Basin, 1420-1440 m depth, over red beds in evaporite-clastic basin fill	111° 58.00' 33° 42.30'	22.65± 0.54	KAWR	44 (74-148)
151	Welded Tuff, AZ	111° 25.68' 33° 28.60'	22.6 ± 1.0	KABIO	14 (PED-18-68)
152	Trachyte, Picacho Peak Summit, AZ	111° 26.00' 32° 38.12'	22.6 ± 0.48	KAWR	43 (75-96)
153	Rhyolite Tuff, Muggins Mtns; may be Kinter Fm	114° 07.90' 32° 45.28'	22.5 ± 0.7	KA	44 (60-23)
154	Rhyolite Tuff, AZ	110° 32.80' 32° 54.87'	22.4 ± 1	KASAN	27
155	Andesite, southern Plomosa Mtns, AZ	114° 01.00' 33° 40.00'	22.4 ± 1.4		24 (RD-17)
156	Trachyandesite, interbedded between two Wymola conglomerate units, Picacho Peak, AZ	111° 23.50' 32° 37.58'	22.39± 0.47	KAWR	43 (75-27)
157	Trachyandesite, Picacho Peak, AZ	111° 23.52' 32° 37.93'	22.35± 0.47	KAWR	43 (75-2')
158	Rhyolite Dike, AZ	110° 45.50' 32° 50.00'	22.3 ± 0.7	KABIO	30
159	Porphyritic Granite, Chocolate Mtns, CA	115° 20.00' 33° 19.00'	22.3 ± 0.7	KABIO	10 (CMG1-35)
160	Hornblende Trachyandesite, Picacho Peak, AZ	110° 23.52' 32° 37.93'	22.21± 0.50	KAHRN	43 (75-85)
161	Perlitic to Feldsophyric Plug Dome, Black Hills, CA	115° 02.00' 33° 24.00'	22.1 ± 1.3	KAPLA	10 (BH-3)
162	Porphyritic Granite, Chocolate Mtns, CA	115° 02.00' 32° 19.00'	22.1	KABIO	10 (CMG1-35)
163	Diorite Dike, cuts metamorphic and granitic rocks in Harquahala Mtns (NW trend)	113° 17.80' 33° 45.70'	22.1 ± 1.3	KABIO	44 (HLa-2)

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164	Basalt, Sperry Gyroscope No 1, 222-271 m depth, spurious date, probably Oligocene or Miocene, AZ	112° 05.85' 33° 41.03'	22 ± 1.9	KABIO	21 (61)
165	Basaltic Andesite, Biery #1 Federal, 1430-1442 depth, AZ	112° 05.00' 33° 41.03'	22 ± 1.2	KAWR	21 (62)
166	Basalt, AZ	113° 28.00' 34° 40.00'	22		21 (84)
167	Porphyritic Granite, Chocolate Mtns, CA	115° 20.00' 33° 20.00'	22.0 ± 0.7	KABIO	10 (CMG1-34)
168	Muggins Mtn Tuff, AZ	114° 07.90' 32° 45.28'	21.9 ± 0.9	KABIO	13 (PED-23-67)
169	Fault Gouge, Dome Rock Mtns, along highway west of Quartzite, AZ	114° 20.00' 33° 38.00'	21.9 ± 1.0	KAMUS	24 (RD-5)
170	Olivine Basalt, Kofa Mtns, over gravel and ash-flow and under andesite, AZ	113° 54.08' 33° 27.50'	21.68± 0.57	KABIO	44 (73-19)
171	Sasco Andesite, flow overlying brecciated andesite, north end of Silver Bell Mtns, AZ	111° 27.88' 32° 32.92'	21.55± 0.45	KABIO	43 (73-141)
172	Volcanic flow, AZ	114° 16.00' 34° 12.00'	21.4 ± 1.0	KAWR	45 (FK-2)
173	Basalt, Tabletop Mtn, AZ	112° 7.36' 32° 44.51'	21.37± 0.53	KAWR	43 (UAKA-75-04)
174	Basalt, AZ	111° 57.21' 33° 53.81'	21.34± 0.46	KAWR	41 (UAKA-77-108)
175	Quartz Latite, AZ	111° 34.75' 33° 28.35'	21.3 ± 0.8	KABIO	13 (PED-17-68)
176	Aphanitic volcanic rock, (14)-1, 799 m depth, Yuma Co, AZ	113° 20.50' 33° 08.27'	21.3 ± 0.9	KAWR	21 (UAKA-72-58)
177	Trachyandesite, east side of Chino Valley, Granite Creek Hills, AZ	112° 20.41' 34° 46.40'	21.28± 0.51	KAWR	44 (76-90)
178	Trachyte, Turtleback Mtn, AZ	113° 23.87' 33° 08.18'	21.03± 0.54	KAWR	44 (72-48)

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179	Basalt, Artillery Fm, AZ	113° 35.57' 34° 19.92'	21 ± 3.6	KAWR	21 (85)
180	Andesite, AZ	113° 55.52' 33° 56.62'	21 ± 1.2	KABIO	21 (90)
181	Basalt, AZ	112° 52.72' 32° 33.05'	21 ± 1.2	KAWR	21 (107)
182	Basalt, Eagle Tail Mtn, (flat lying), AZ	113° 26.50' 33° 32.92'	20.9 ± 0.53	KAWR	44 (73-107)
183	Andesite, south end of Turtle Mtns, CA	114° 51.60' 34° 08.80'	20.8 ± 0.8	KAWR	45 (C-598)
184	Ultrapotassic Trachyte, Picacho Peak, AZ	111° 23.43' 32° 39.83'	20.72± 0.50	KAWR	43 (75-29)
185	Basalt, lowermost flows in Palos Verde Hills, AZ	112° 48.80' 33° 23.30'	20.70± 0.5	KAWR	23,44 (P-5, (UAKA-75-33)
186	Tuff, north Muddy Mtns, NV	114° 31.87' 36° 39.17'	20.7 ± 1.2	F.TRACK	6 (31)
187	Andesitic Basalt tuff, Rox Conglomerate, NV	114° 40.00' 36° 53.00'	20.7 ± 0.5	KABIO	44 (75-06)
188	Dacite, Superstition Mtns, AZ	111° 27.42' 33° 31.18'	20.60± 0.62	KABIO	44 (68-16)
189	Andesite, Exxon State (14)-1, 288-299 m depth, Yuma Co, AZ	113° 20.50' 33° 08.27'	20.5 ± 1.0	KAWR	21 (72-54)
190	Olivine Basalt, near freeway, Picacho Peak area, AZ	112° 18.38' 32° 50.51'	20.44± 0.45	KAWR	43 (74-39)
191	Andesitic Basalt, Gillespie Dam, AZ	112° 46.30' 33° 23.90'	20.41± 0.52	KAWR	23,44 (G-9, 73-8)
192	Andesitic Basalt, west abutment, Gillespie Dam, AZ, surrounded by Gillespie Flow	112° 46.30' 33° 13.70'	20.41± 52	KAWR	44 (73-08)
193	Andesite Dike, Palo Verde Hills, AZ	112° 55.00' 33° 23.90'	20.36± 0.4	KAWR	23,44 (P-2d, 75-31)
194	Basaltic Andesite, Palo Verde Hills, AZ	112° 56.00' 33° 24.00'	20.35± 0.63	KAWR	23,44 (P-3, 73-29)
195	Andesite, south end of Turtle Mtns, CA	114° 50.00' 34° 09.00'	20.3 ± 0.8	KAWR	45 (C-600)
196	Basalt, northern Kofa Mtns, AZ	113° 58.00' 33° 30.00'	20.3 ± 1.0		24 (RD-18)

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197	Rhyodacite, near Black Mesa, AZ	114° 02.58' 33° 35.17'	20.2 ± 0.6	KABIO	37
198	Silicic Ash, Jim Thomas Wash, San Manuel Fm., Crozier Peak Quad, AZ	110° 56.71' 32° 58.75'	20.11± 0.47	KABIO	41 (76-133)
199	Dacite Dome, near Hackberry Mesa, AZ	111° 27.42' 33° 31.18'	20.1 ± 1.2	KABIO	14 (PED-16-68)
200	Volcanic, Savahia Peak Volcano, CA	114° 33.00' 34° 33.00'	20.1 ± 0.8	KAWR	45 (S-1)
201	Basalt, near Black Butte, Vulture Mtns, AZ	113° 02.80' 33° 51.62'	20.02± 0.42	KAWR	41 (78-48)
202	Andesitic Basalt Exxon-Yuma Federal No. 1, 3078-3108 m dikes or sills; spurious date, Precambrian gneiss with Laramide recrystallization	114° 44.50' 32° 29.67'	20 ± 10.0	KAWR	21 (115)
203	Basaltic Andesite, dark hill between Gila Bend Mtns and Buckeye Hills, AZ	112° 48.20' 33° 12.70'	20 ± 0.49	KAWR	23 (G-7, 73-27)
204	Basalt, John Jacobs Probe No. 2, 380-382 m depth, AZ	112° 07.93' 33° 34.50'	20 ± 2.6	KAWR	21 (58)
205	Basalt, underlies white tuff and clastics, AZ	112° 07.60' 33° 58.17'	20 ± 1.3	KAWR	21 (63)
206	Basalt, Black Peak, AZ	114° 13.08' 34° 07.30'	20 ± 3.1		21 (89)
207	Volcanic Ash, under Overton Fanglomerate and over Horse Spring Fm, north Muddy Mtns, NV	114° 31.67' 36° 38.50'	20 ± 0.8	KABIO	44 (64-21)
208	Latite Porphyry Dike, Courthouse Rock, Eagle Tail Mtns, AZ	113° 21.35' 33° 27.80'	19.98± 0.58	KABIO	44 (72-72)
209	Lava Flow, Palo Verde Hills, AZ	112° 47.50' 33° 26.80'	19.91± 0.58	KAWR	23,44 (P-7, UAKA-73-22)
210	Superior Dacite, ash-flow overlying Whitetail Conglomerate, AZ	111° 05.00' 33° 18.60'	19.9 ± 0.9	KABIO	12 (PED-4-62)
211	Biotite Quartz Diorite, Mesquite Mtn, AZ	114° 18.00' 33° 58.00'	19.9 ± 0.8		24 (RD-15)

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212	Rhyolite Flow, Rawhide Mtns, AZ	113° 36.13' 34° 22.13'	19.90± 0.47	KAWR	41 (78-46)
213	Uppermost Basaltic Andesite, Tumamoc Hill, eastern side of Tucson Mtns, AZ	111° 00.33' 32° 12.78'	19.8 ± 3.0	KAWR	4 & 21 (PED-8-63 & 20)
214	Samaniego Andesite, SW Cerro Prieto, Samaniego Hills, Pinal-Pima Co line, AZ	111° 26.00' 32° 32.00'	19.8 ± 1.2	KAWR	20, 21 (RLE-27-68 & 8)
215	Andesite, southern end of Turtle Mtns, CA	114° 50.00' 34° 09.00'	19.8 ± 0.2	KAWR	45 (C-599)
216	Basalt, Bear Hills, AZ	113° 55.00' 33° 40.00'	19.7 ± 0.9		24 (RD-12)
217	Basalt, Gillespie flow, AZ	112° 49.00' 33° 14.00'	19.6 ± 1.0		23 (G-4, R-2639)
218	Basaltic Andesite, Palo Verde Hills, AZ	112° 52.60' 33° 26.80'	19.58± 0.88	KAWR	23,44 (P-4,73-30)
219	Granodiorite, western end of White Tank Mtn, AZ	112° 37.60' 33° 36.90'	19.58± 0.53	KABIO	44 (73-14)
220	Rhyolite Tuff, under gravel and basalt, Black Mesa, New Water Mtns, AZ	114° 02.49' 33° 35.16'	19.41± 0.47	KABIO	44 (74-38)
221	Pyroclastic Rock, drill hole in Higley Basin; 2400-2420 m depth (maximum age of basin), AZ	111° 41.30' 33° 17.00'	19.40± 0.47	KABIO	44 (74-130)
222	Basalt, Gillespie flow, AZ	112° 50.00' 33° 14.00'	19.3 ± 1.0		23 (G-1,R-2638)
223	Volcanic, near Parker, AZ	114° 16.00' 34° 12.00'	19.2 ± 0.7	KAWR	45 (FK-1)
224	Basalt, lowermost flow near summit of Lookout Mtn, AZ (north of Phoenix)	112° 02.70' 33° 37.40'	19.20± 0.47	KAWR	44 (74-149)
225	Rhyodacite, near Black Mesa, AZ	114° 02.58' 33° 35.17'	19.1 ± 0.6	KAHBN	37
226	Basalt, Gillespie flow, AZ	112° 49.00' 33° 15.00'	19.1 ± 0.9	KAWR	23 (G-2, R-2640)
227	Andesite, southern end of Turtle Mtns, CA	114° 51.60' 34° 08.80'	19.0 ± 1.5	KA	45 (C-597)

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228	Augite-Hypersthene Dacite, E of Orocopia Mtns, CA	115° 34.00' 33° 31.00'	19.0 ± 0.6	KAPLA	10 (CG-27)
229	Volcanic Flow, Whipple Mtns, CA	114° 20.00' 34° 14.00'	18.9 ± 0.9	KAWR	45 (V-1)
230	Rhyolite Dome, E of Orocopia Mtns, CA	115° 33.00' 33° 30.00'	18.8 ± 0.2	KAPLA	10 (CG-32)
231	Trachyte, brecciated boulder in red-bed fanglomerate, near Orme Dam, AZ	111° 41.24' 33° 32.43'	18.70± 0.44	KAWR	44 (77-147)
232	Basal Vitrophyre of Dacite Lava, Patsy Mine Volcanics, Nelson, NV	114° 52.83' 35° 48.00'	18.6 ± 0.3	KAHBN	1 (42)
233	Altered Ash-Flow Tuff, Patsy Mine Volcanics, Black Mtns, AZ	114° 36.05' 35° 46.62'	18.6 ± 0.7	KAWR	1 (43)
234	Andesite, Palo Verde Hills, AZ	112° 57.00' 33° 26.00'	18.52± 0.56	KAWR	23,44 (P-1,73-21)
235	Leucocratic Rhyolite, Turtleback Mtn, AZ	113° 23.87' 33° 08.18'	18.5 ± 1.5	KAWR	21 (72-48)
236	Latite Dome Bradshaw Mtns, AZ	112° 11.50' 34° 21.00'	18.5 ± 0.6	KAHBAN	36 (MY-1)
237	Aplitic Granite, Woodcamp Cyn stock, Reeves Cyn, AZ	111° 07.67' 33° 21.75'	18.35± 0.38	KABIO	44 (73-109)
238	Basalt, north end of Saguaro Lake, AZ	111° 32.54' 33° 34.53'	18.31± 0.46	KAWR	44 (77-145)
239	Basaltic Andesite, highest mesa-capping lava, Kofa Mtns	113° 53.00' 33° 29.00'	18.31± 0.42	KAWR	44 (73-108)
240	Basalt, Austin Creek, AZ	113° 29.92' 35° 04.72'	18.2 ± 1.5	KAWR	46
241	Porphyritic Rhyolite Dike, Vulture Mtns, AZ	112° 50.40' 33° 56.80'	18.2 ± 0.4	KABIO	40 (72-44)
242	Quartz Latite, uppermost formation on Picketpost Mtn, AZ	111° 09.35' 33° 15.33'	18.2 ± 2.5	KAPLA	12 (PED-11-65)
243	Basalt, Stewart Mtn, AZ	111° 34.78' 33° 33.54'	18.15± 0.44	KAWR	44 (77-144)
244	Trachyte, autobrecciated, overlies Trachyte boulder, near Orme Dam, AZ	111° 41.12' 33° 32.18'	18.01± 0.43	KAWR	44 (77-144)

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245	Quartz Latite, uppermost formation on Picketpost Mtn, AZ	111° 09.35' 33° 15.33'	18.0 ± 0.5	KABIO	12 (PED-11-65)
246	Basalt, New Water Mtns, AZ	114° 00.00' 33° 35.00'	18.0 ± 1.0		24 (RD-20)
247	Andesitic basalt, Exxon State (32) No 1, 2972-3002 m depth	110° 48.00' 31° 56.00'	18.0 ± 2.0	KAWR	21 (72-70)
248	Basalt, Gila Bend Mtns, AZ	112° 59.97' 33° 01.05'	18 ± 7.2	KAWR	21 (100)
249	Latite Porphyry, hydrothermally altered, Buckhorn Mtns, AZ	112° 26.13' 34° 01.17'	17.98± 0.43	KABIO	44 (72-71)
250	Basalt, uppermost unit, Palo Verde Hills, AZ	112° 51.10' 33° 21.20'	17.9 ± 0.7	KAWR	23,44 (P-6,73-32)
251	Rhyolite Glass, near Black Mesa, AZ	113° 40.32' 34° 24.83'	17.9 ± 0.5	KABIO	25 (KA-1236)
252	Andesite Dike (vertical, N60E), Gunnery Range Granite, south Cabeza Prieta Mtns, AZ	113° 50.66' 32° 14.71'	17.81± 0.52	KAHBN	44 (76-41)
253	Basalt, near Hackberry Mesa, AZ	111° 28.03' 33° 31.43'	17.8 ± 3.1	KAWR	14 (PED-14-68)
254	Basaltic andesite, Apache Peak, AZ	112° 04.12' 33° 53.24'	17.72± 0.37	KAWR	41 (78-42)
255	Rhyolite Ash-Flow, overlies trachyte and red bed fanglomerates near Orme Dam, AZ	111° 41.12' 33° 32.15'	17.71± 0.43	KAWR	44 (77-149)
256	Cerro Prieto Basalt, Cerro Prieto, Samaniego Hills, Pinal-Pima Co line, AZ	111° 26.00' 32° 31.00'	17.6 ± 1.3		20 & 21 (RLE-27-67)
257	Basaltic Andesite, Phoenix, AZ	111° 56.04' 33° 25.68'	17.56± 0.37	KAWR	41 (78-34)
258	Rhyodacite, Bear Hills, AZ	113° 55.00' 33° 40.00'	17.4 ± 0.7	KAWR	24 (RD-11)
259	Rhyolite, overlies Childs Latite, Organ Pipe Nat'l Mon., AZ	112° 42.53' 32° 04.03'	17.4 ± 0.5	KAWR	44 (72-42)
260	Ultrapotassic Trachyte, AZ	111° 09.60' 34° 12.35'	17.35± 0.5	KAWR	41 (78-30)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
261	Olivine Basalt, mesa-capping flow, Black Mesa, dips 50°S and overlies gravel and rhyolite tuff, AZ	114° 02.01' 33° 35.27'	17.9 ± 0.5	KABIO	25 (74-37)
262	Pyroxene-Olivine Andesite, Thumb Fm., Rainbow Gardens, NV	114° 56.63' 37° 07.45'	17.2 ± 3	KAWR	1 (12)
263	Basalt, Palo Verde Mtns, CA	114° 53.00' 33° 26.00'	17.2 ± 0.9	KAWR	24 (RD-6)
264	Basalt, Palo Verdes Mtns, CA	114° 53.00' 33° 25.00'	17.2 ± 0.9	KAWR	24 (RD-7)
265	Quartz-Biotite Gneiss, Mesquite Mtn, AZ	114° 17.00' 33° 59.00'	17.1 ± 0.7		24 (RD-13)
266	Rhyolite Cataclastic Gouge, in low angle fault, Vulture Mtns, AZ	112° 48.40' 33° 55.80'	17.1 ± 0.4	KAWR	40 (75-53)
267	Basalt, Exxon State (74) No 1, 2792-2807 m depth, west of Picacho Mtns, AZ	111° 29.73' 32° 45.70'	17 ± 1.0	KAWR	21 (5)
268	Diorite Porphyry, Eldorado Mtns, NV	114° 55.00' 36° 42.00'	16.9 ± 0.3	KAWR	1 (53,54,55)
269	Basaltic Andesite, borehole PV-33, 100 m depth, Palo Verde Nuclear Generating Station, AZ	112° 51.99' 33° 21.77'	16.87± 0.42	KAWR	23,44 (P-8,73-94)
270	Porphyritic Hypersthene-Augite-Olivine Andesite	115° 16.00' 33° 19.00'	16.8 ± 4.4	KAPLA	10 (AP-10)
271	Basaltic Andesite (Trachyandesite), Vulture Mtns, AZ	112° 50.00' 33° 56.90'	16.7 ± 1.1	KAWR	40 (72-60)
272	Basaltic Andesite, Lake Pleasant, AZ	112° 17.97' 33° 53.78'	16.63± 0.35	KAWR	41 (78-40)
273	Basaltic Andesite, N of Wickenburg, AZ	112° 43.60' 34° 02.72'	16.57± 0.35	KAWR	41 (79-66)
274	Granodiorite Stock, Bouse, AZ	113° 49.80' 33° 58.10'	16.46± 0.50 (Cooling age)	KAWR	24 (79-127)
275	Basalt, Black Peak, AZ	114° 13.28' 34° 07.20'	16.4 ± 0.7	KAWR	15 (PED-7-68)
276	Tuff, Thumb Member, Wecheck Basin, Virgin Mtns, AZ	114° 09.23' 36° 29.42'	16.3 ± 1.9	F. TRACK	6 (36)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
277	Rhyolite, Vulture Mtns, AZ	112° 48.40' 33° 53.80'	16.3 ± 0.3	KAWR	40 (72-13)
278	Basalt, Artillery Mtns, AZ	113° 37.00' 34° 21.00'	16.28± 0.40 (minimum age of deformation)	KAWR	44 (74-04)
279	Basalt, Rawhide-Artillery Mtns, AZ	113° 37.00' 34° 21.00'	16.2 ± 0.4	KAWR	42
280	Tuff, Thumb Member, Lava Butte, NV	114° 54.25' 36° 10.78'	16.2 ± 0.8	F. TRACK	6 (22)
281	Basaltic Andesite, interbedded with fang-glomerate, near Parker, AZ	114° 13.15' 34° 10.64'	16.16± 0.95	KAWR	44 (68-06)
282	Basaltic Andesite, uppermost flow, Black Peak, AZ	114° 13.28' 34° 07.20'	16.14± 0.75	KAWR	44 (68-07)
283	Andesite, Cabeza Prieta Volcanics, AZ	113° 48.61' 32° 17.19'	16.12± 0.41	KAWR	44 (77-122)
284	Basal Vitrophyre of Rhyo-dacite Lava, Patsy Mine Volcanics, Nelson, NV	114° 52.22' 35° 37.00'	16.1 ± 0.6	KASAN	1 (37)
285	Andesitic basalt (dike?), Exxon State (32) No 1, 2895-2898 m depth	110° 48.00' 31° 56.00'	16.1 ± 0.6	KAWR	21 (72-70)
286	Tuff, Thumb Member, Lava Butte, NV	114° 55.00' 36° 11.17'	16.1 ± 1.5	F. TRACK	6 (21)
287	Rhyolite Dike (vertical), Vulture Mtns, AZ	112° 49.00' 33° 53.80'	16.1 ± 0.4	KAWR	40 (72-35a)
288	Rhyolite Dike (vertical), Vulture Mtns, AZ	112° 49.00' 33° 53.80'	16.1 ± 0.4	KAWR	440 (71-356)
289	Andesitic Tuff, dike or sill, Exxon Yuma-Federal No 1, 2194-2224 m depth	114° 44.50' 32° 29.67'	16 ±31.9	KAWR	21 (115)
290	Granite, Newberry Mtns, pluton, NV	114° 43.50' 35° 15.33'	15.9 ± 0.3	KABIO	1 (57)
291	Non-vesicular Basalt, near Black Mesa, AZ	113° 37.00' 34° 21.00'	15.9 ± 0.3	KAWR	(25) (74-4)
292	Tuff, Thumb Member, Wecheck Basin, Virgin Mtns, NV	114° 09.67' 36° 29.22'	15.9 ± 1.0	F. TRACK	6 (35)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
293	Basal Vitrophyre of Dacite Lava, Patsy Mine Volcanics, Nelson, NV	114° 52.83' 35° 48.00'	15.8 ± 0.2	KABIO	1 (41)
294	Andesite, Harcuvar Mtns, AZ	113° 17.08' 35° 02.97'	15.77± 0.32	KAWR	41 (78-49)
295	Rhyolite, E of Ajo Range, AZ	112° 33.08' 31° 57.50'	15.71± 0.40	KAWR	44 (72-40)
296	Granite, Knob Hill Pluton, Eldorado Mtns, NV	114° 51.00' 35° 39.67'	15.7 ± 0.3	KABIO	1 (56)
297	Basalt, Black Butte, AZ	113° 01.87' 33° 50.76'	15.62± 0.35	KAWR	41 (78-31)
298	Pyroxene-olivine andesite, Thumb Formation, Rainbow Gardens, NV	114° 56.63' 37° 07.45'	15.6 ± 3	KAWR	1 (12)
299	Tuff, Thumb Member, Bitter Spring Valley, NV	114° 36.20' 36° 18.25'	15.6 ± 1.0	F. TRACK	6 (24)
300	Tuff, Thumb Member, Overton Ridge, NV	114° 28.92' 36° 30.92'	15.6 ± 0.9	F. TRACK	6 (30)
301	Basaltic Andesite, near Stewart Mtn, AZ	111° 33.27' 33° 36.68'	15.53± 0.39	KAWR	(44) (77-146)
302	Batamote Andesite, AZ	112° 48.20' 32° 25.60'	15.52± 0.54	KAWR	44 (72-64)
303	Basal Vitrophyre of Rhyodacite Lava, Patsy Mine Volcanics, Nelson, NV	114° 51.67' 35° 45.25'	15.5 ± 0.7	KABIO	1 (40)
304	Tuff, Thumb Member, Bitter Spring Valley, NV	114° 34.08' 36° 17.45'	15.4 ± 0.8	F. TRACK	6 (23)
305	Basalt Dike, Skunk Creek, AZ	112° 08.87' 33° 48.70'	15.39± 0.40	KAWR	41 (78-44)
306	Basalt, (horizontal) Gu Vo Hills, Organ Pipe Nat'l Mon., AZ	112° 32.84' 31° 55.35'	15.39± 0.45	KAWR	44 (72-41)
307	Tuff, Horse Springs Fm, Bitter Spring, NV	114° 36.00' 36° 30.00'	15.3 ± 0.7	KABIO	1 (3)
308	Basal Vitrophyre of Rhyodacite Lava, Patsy Mine Volcanics, Nelson, NV	114° 50.67' 35° 45.00'	15.3 ± 0.6	KABIO	1 (36)
309	Tuff, Thumb Member, Echo Wash, NV	114° 29.75' 36° 17.75'	15.3 ± 2.0	F. TRACK	6 (37)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
310	Sasco Andesite, west of Cerro Prieto, Samaniego Hills, Pinal-Pima Co. Line, AZ	111° 28.00' 32° 32.00'	15.2 ± 4.8	KAWR	20 & 21 (RLE-20-68 & 6)
311	Basalt, Black Peak, AZ	114° 13.28' 34° 07.20'	15.1 ± 4.4	KAWR	15 (PED-7-68)
312	Tuff, Horse Spring Fm., Muddy Mtns, NV	114° 45.50' 36° 14.90'	15.1 ± 0.5		4 (5)
313	Granite, Wilson Ridge Pluton, Black Mtns, AZ	114° 38.62' 36° 02.70'	15.1 ± 0.6	KABIO	1 (58)
314	Tuff, Rainbow Gardens Member, Horse Spring Fm., Virgin Mtns, NV	114° 07.97' 36° 20.67'	15.1 ± 0.8	F. TRACK	6 (37)
315	Ultrapotassic Trachyte, in drillhole, 2341-2345 m depth; between conglomerates, AZ	111° 30.00' 32° 45.00'	15.08± 0.34	KAWR	43 (73-140)
316	Basalt, Hot Rock Hill, Belmont Mtns, AZ	112° 52.83' 33° 35.14'	15.01± 0.42	KAWR	23 (BM-1, 73-10)
317	Granite, Keyhole Canyon Pluton, Eldorado Mtns, NV	114° 55.00' 36° 42.00'	15.0 ± 0.6	KABIO	1 (53,54,55)
318	Basalt, probably Hickey Fm, overlies white tuff and clastics, AZ	112° 06.50' 34° 04.33'	15 ± 2.1	KAWR	21 (64)
319	Basalt (Batamote Andesite), overlies Daniels conglomerate	113° 00.43' 32° 18.33'	15 ± 2.2	KAWR	21 (109)
320	Tuff, Thumb Member, Overton Ridge, NV	114° 28.92' 36° 30.92'	15.0 ± 0.8	F. TRACK	6 (39)
321	Basalt, Ultrapotassic trachyte, Exxon State (74) No 1, 2823-2924 m depth, west of Picacho Mtns, AZ	111° 29.73' 32° 45.70'	14.9 ± 0.3 (average age)	KAWR	43 (73-140, 74-87)
322	Tuff (?), Horse Spring Formation, Muddy Mtns, NV	114° 48.00' 36° 13.00'	14.9 ± 0.5	KA	1 (4)
323	Basalt, Cave Creek area, AZ	111° 55.18' 33° 55.42'	14.81± 0.79	KAWR	41 (77-106)
324	Latite, Milk Creek Fm, AZ	112° 31.80' 34° 18.95'	14.8 ± 0.5	KABIO	36 (K2)
325	Tuff, Thumb Member, Lava Butte, NV	114° 54.75' 36° 11.17'	14.8 ± 1.4	F. TRACK	6 (20)

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326	Pyroxene Andesite, north side of Verde River, near Bartlett Dam, AZ	111° 39.50' 33° 48.54'	14.78± 0.40	KAWR	44 (77-151)
327	Basalt, Vulture Mtns, AZ	112° 57.78' 33° 54.72'	14.67± 0.35	KAWR	41 (78-36)
328	Ultrapotassic Trachyte, in drillhole at 2420-2442 m depth; part of 185 m thick volcanic sequence	111° 30.00' 32° 45.00'	24.66± 0.34	KAWR	43 (74-87)
329	Basalt, near Horseshoe Dam, AZ	111° 42.70' 33° 58.87'	14.64± 0.37	KAWR	41 (78-38)
330	Trachyandesite, Hickey Fm, AZ	112° 06.42' 34° 44.48'	14.6 ± 1.1	KABIO	31 (mm4)
331	Latite, Mill Creek Fm, AZ	112° 34.75' 34° 18.40'	14.6 ± 0.5	KABIO	36 (K3)
332	Basalt, Mt. Davis Volcanics, Mt. Davis, AZ	114° 37.50' 35° 31.70'	14.6 ± 0.3	KAWR	1 (33)
333	Basaltic Andesite, Vulture Mtns, AZ	112° 44.80' 33° 48.20'	14.51± 0.2	KAWR	44 (73-11)
334	Granite, Keyhole Canyon Pluton, Eldorado Mtns, NV	114° 55.00' 36° 22.00'	14.5 ± 0.4	KAFEL	1 (53,54,55)
335	Basal Vitrophyre of Rhyodacite, Patsy Mine Volcanics, Nelson, NV	114° 51.67' 35° 45.25'	14.5 ± 0.6	KASAN	1 (39)
336	Dacite Porphyry Dike, Mt. Davis Volcanics, Nelson, NV	114° 49.50' 35° 44.33'	14.5 ± 0.3	KABIO	1 (32)
337	Basal Vitrophyre, tuff of Bridge Spring, Nelson, NV	114° 52.88' 35° 47.37'	14.5 ± 0.6	KAWR	1 (34)
338	Basal Vitrophyre, tuff of Bridge Spring, Nelson, NV	114° 52.88' 35° 47.37'	14.4 ± 0.5	KAWR	1 (35)
339	Hackberry Mountain Tuff, Hickey Fm, south end of Verde Valley, Az	27 km east of location 410	14 ± 7	KABIO	11 (BES-58-282)
340	Basalt, Hickey Fm, west side of Verde Valley, AZ	112° 07.05' 34° 45.33'	14.0 ± 0.6	KAWR	36 (CD1)
341	Basalt, north end of Aquila Mtn, (dips 10° N), AZ	113° 20.57' 34° 18.40'	14.00± 0.32	KAWR	44 (79-55)

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342	Basalt, over gravel, NE side of Verde Valley, AZ	111° 47.01' 34° 44.10'	13.9 ± 1.6	KAWR	44 (66-55)
343	Trachyte dike or sill, 20 m above crystalline basement, Exxon drillhole 14-01, 675-690 m depth	113° 21.00' 33° 08.00'	13.9 ± 0.3	KAWR	44 (74-118)
344	Basalt, Mt Davis Volcanics, Nelson, NV	114° 48.63' 35° 46.78'	13.8 ± 0.2	KAWR	1 (28)
345	Grandiorite Porphyry, Boulder City Pluton, Boulder City, NV	114° 49.50' 35° 59.50'	13.8 ± 0.6	KABIO	1 (48)
346	Adamellite, Railroad Pass Pluton, Boulder City, NV	114° 55.00' 25° 58.00'	13.8 ± 0.6	KABIO	1 (52)
347	Basalt, Black Peak, AZ	114° 13.00' 34° 07.00'	13.7 ± 0.7		24 (RD-21)
348	Adamellite, Wilson Ridge Pluton, Black Mtns, AZ	114° 38.88' 36° 02.62'	13.6 ± 0.6	KABIO	1 (59)
349	Basalt Dike, near Apache Peak, AZ	112° 03.50' 33° 54.25'	13.60± 0.34	KAWR	41 (78-43)
350	Basaltic Andesite, Thumb Formation, NV	114° 46.00' 36° 09.00'	13.56± 0.50	KAWR	44 (65-10)
351	Basalt, Hickey Fm., Big Bug Mesa, Bradshaw Mtns, AZ	112° 41.75' 34° 18.40'	13.5 ± 0.5	KAWR	36 (MU-2)
352	Volcanic, Buckskin Mtns, CA	114° 15.00' 34° 11.00'	13.5 ± 1.0	KAWR	45 (F-1)
353	Olivine Basalt, caps mesa, Black Mtn, north, AZ	112° 51.10' 33° 58.00'	13.5 ± 0.3	KAWR	40 (72-43)
354	Basalt, Hickey Fm., Glassford Hill, SW side of Chino Valley, AZ	112° 22.50' 34° 34.75'	13.4 ± 0.5	KAWR	36 (PR-2)
355	Biotite-Hornblende Rhyo-dacite, Thumb Fm., Rainbow Gardens, NV	114° 56.42' 36° 07.83'	13.4 ± 0.7	KABIO	1 (8)
356	Andesite, N20W, 15SW, faulted (N30W), Mexico	113° 23.10' 32° 01.00'	13.35± 0.32	KAWR	44 (76-123)
357	Basalt, Hickey Fm., AZ	112° 08.50' 34° 42.20'	13.3 ± 0.5	KAWR	36 (MM1)

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358	Basalt, Horse Spring Fm, Callville Mesa, NV	114° 46.00' 36° 09.00'	13.2 ± 0.5		1 (6)
359	Silicic Lava, Mt Davis Volcanics, River Mtns, NV	114° 51.67' 36° 01.72'	13.2 ± 0.3	KABIO	1 (29)
360	Silicic Lava, Mt Davis Volcanics, River Mtns, NV	114° 50.00' 36° 02.50'	13.2 ± 0.3	KABIO	1 (30)
361	Hickey Fm, above Haywood Springs, AZ	112° 08.40' 34° 42.00'	13.2 ± 0.8	KAWR	44 (67-09)
362	Tuff, Thumb Member, Lava Butte, NV	114° 56.50' 36° 08.33'	13.2 ± 0.9	F. TRACK	6 (34)
363	Basalt, Black Mtns, AZ	113° 16.62' 34° 18.18'	13.19± 0.29	KAWR	41 (77-70)
364	Basalt, Hickey Fm, AZ	112° 11.15' 34° 18.35'	13.1 ± 0.5	KAWR	36 (MY5)
365	Basalt, Hickey Fm, Prescott, AZ	112° 26.35' 34° 34.73'	13.1 ± 0.5	KAWR	36 (PR3)
366	Basalt, Mt. Davis Volcanics, Fire Mtn, AZ	114° 38.48' 35° 40.58'	13.1 ± 0.2	KAWR	1 (31)
367	Diorite Porphyry, River Mtns Stock, River Mtns, NV	114° 50.83' 36° 01.50'	13.1 ± 0.5	KABIO	1 (49,50,51)
368	Augite-Olivine Basalt, Chocolate Mtns, CA	114° 50.83' 33° 05.17'	13.1 ± 2.5	KAPLA	9 (PP-100)
369	Augite-Olivine Basalt, Chocolate Mtns, CA	114° 52.00' 33° 05.00'	13.1 ± 2.5		10 (PP-100)
370	Lava Flow, capping Government and Black Hills over Hickey Fm, SW edge of Verde Valley, AZ	111° 56.23' 34° 31.11'	13.1 ± 1.6	KAWR	44 (66-28)
371	Cobwebb Basalt, AZ	113° 36.20' 34° 19.28'	13 ± 2.1	KAWR	21 (86)
372	Tuff, Lovell Wash Member, Lovell Wash, NV	114° 42.25' 36° 12.62'	13.0 ± 0.8	F. TRACK	6 (28)
373	Mingus Mountain Basalt, Hickey Fm, AZ	112° 08.35' 34° 42.17'	12.9 ± 0.8	KAWR	13 (PED-28-66)
374	Black Hills Basalt, Hickey Fm, Black Canyon Highway, AZ	111° 56.23' 34° 32.12'	12.8 ± 2.2	KAWR	13 (PED-28-66)
375	Andesite, upper part of volcano, Mt Davis Volcanics, Echo Bay, NV	114° 25.83' 36° 16.75'	12.7 ± 0.8	KAWR	1 (27)

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376	Rhyodacite, Recortada ash-flow, Roskruge Mtns, AZ	111° 21.40' 32° 10.73'	12.6 ± 0.6	KASAN	3 & 21 (MB-3-64&13)
377	Rhyolite, Devils Peak Stock, Spring Mtns, NV	115° 27.00' 35° 41.67'	12.6 ± 0.3	KAWR	1 (47)
378	Biotite Dacite Porphyry, River Mtns Stock, River Mtns, NV	114° 50.83' 36° 01.17'	12.6 ± 0.5	KABIO	1 (49,50,51)
379	Dacite Porphyry, River Mtns Stock, River Mtns, NV	114° 50.81' 36° 01.17'	12.5 + 0.5		1 (49.50,51)
380	Tuff, Thumb Member, Overton Ridge, NV	114° 28.92' 36° 30.92'	12.5 ± 0.9	F. TRACK	6 (40)
381	Basalt Flow, Aquarius Mtns, AZ	113° 32.93' 34° 48.15'	12.19± 0.22	KAWR	41 (78-45)
382	Basalt, Mt Davis Volcanics, Hoover Dam, AZ	114° 43.30' 36° 05.00'	12.0 ± 0.2	KAWR	1 (26)
383	Trachyte Sill, Thumb Fm, Frenchman Mtns, NV	114° 57.10' 36° 07.60'	11.9 ± 0.7	KAWR	33 (65-01)
384	Tuff, red sandstone unit, White Basin, NV	114° 38.17' 36° 19.57'	11.9 ± 0.9	F. TRACK	6 (25)
385	Mafic, alkalic igneous rock, Thumb Fm, Rainbow Gardens, NV	114° 58.58' 36° 07.25'	11.8 ± 1.0	KAWR	1 (10)
386	Mafic, alkali igneous rock, Thumb Fm, Rainbow Gardens, NV	114° 58.58' 36° 07.25'	11.8 ± 0.7	KAWR	1 (10)
387	Basaltic Andesite, Mt Davis Volcanics, River Mtns, NV	114° 53.78' 36° 04.78'	11.8 ± 0.5	KAWR	1 (25)
388	Biotite-Hornblende Rhyodacite, Thumb Fm, Rainbow Gardens, NV	114° 56.42' 36° 07.83'	11.7 ± 2.0	KABIO	1 (9)
389	Tuff, red sandstone unit, White Basin, NV	114° 38.17' 36° 19.57'	11.7 ± 1.3	F. TRACK	6 (26)
390	Basalt, Hickey Fm, Mingus Mtn, between Verde and Chino Valleys, AZ	112° 07.25' 34° 41.95'	11.6 ± 0.5	KAWR	36 (MM2)
391	Tuff, Grand Wash, Pierce Ferry, NV, underlies tuff at location 401	114° 01.58' 36° 07.62'	11.6 ± 1.2	F. TRACK	6 (42)
392	Basalt, Fortification Basalt, Callville Wash, NV	114° 41.22' 36° 10.17'	11.3 ± 0.3	KAWR	1 (22)

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393	Sill in Thumb Fm, Frenchman Mtns, NV	114° 57.00' 36° 07.90'	11.2 ± 0.9	KAWR	44 (66-05)
394	Tuff, red sandstone unit, Lava Butte, NV	114° 54.25' 36° 09.33'	11.2 ± 1.2	F. TRACK	6 (33)
395	Tuff, red sandstone unit, White Basin, NV	114° 39.08' 36° 19.92'	11.2 ± 1.1	F. TRACK	6 (27)
396	Crystalline Interior of Basalt, Fortification Basalt, Callville Wash, NV	114° 46.00' 36° 09.92'	11.1 ± 0.5	KAWR	1 (24)
397	Tuff, Grand Wash, Pierce Ferry, NV	114° 01.58' 36° 07.62'	11.1 ± 1.3	F. TRACK	6 (43)
398	Basalt, Hickey Fm, Estler Peak, AZ	112° 00.30' 34° 22.85'	11.0 ± 0.5	KAWR	36 (MY7)
399	Tuff, red sandstone unit, White Basin, NV	114° 40.47' 36° 20.75'	11.0 ± 0.9	F. TRACK	6 (29)
400	Mafic, alkalic igneous rock, Thumb Fm., Rainbow Gardens, NV	114° 57.37' 36° 06.33'	10.9 ± 1.1	KAWR	1 (7)
401	Tuff, Grand Wash, Pierce Ferry, NV	114° 01.58' 36° 07.62'	10.8 ± 0.8	F. TRACK	6 (41)
402	Basalt, Fortification Basalt, Fortification Hill, AZ	114° 39.58' 36° 02.75'	10.6 ± 1.1	KAWR	1 (23)
403	Tuff, red sandstone unit, Lava Butte, NV	114° 55.17' 36° 08.42'	10.6 ± 0.9	F. TRACK	6 (32)
404	Basalt, 315 m depth in bore-hole, Luke Basin, Goodyear, AZ	112° 22.00' 33° 30.50'	10.52± 0.61	KAWR	44 (73-239)
405	Basalt, 469-487 m depth, Goodyear Farms water well, AZ	112° 19.65' 33° 30.95'	10.5 ± 4.5	KAWR	21 (59)
406	Basalt, capping westernmost Mesa de Malpai, Sonora, Mexico	113° 56.50' 32° 10.00'	10.49± 0.41	KAWR	44 (76-100)
407	Basalt, Roskruge Mtns, AZ	111° 19.28' 32° 05.83'	10.4 ± 1.3	KAWR	3 & 21 (MB-7-64)
408	Basalt, Hickey Fm, AZ	112° 02.37' 34° 16.70'	10.4 ± 0.4	KAWR	36 (MY6)
409	Olivine Basalt, Malpai Mesa, Yavapai Co, AZ	113° 05.90' 34° 19.41'	10.02± 0.35	KAWR	44 (74-36)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
410	Basalt, Hickey Fm, Estler Peak, AZ	112° 02.85' 34° 27.45'	10.1 ± 0.4	KAWR	36 (MY8)
411	Basalt Dike, Roskruge Mtns, AZ	111° 22.23' 32° 12.57'	9.7 ± 1.7	KAWR	3 & 21 (MB-17-64)
412	Basalt, Big Sandy Fm, AZ	113° 23.58' 34° 34.32'	9.62± 0.38	KAWR	44 (70-13)
413	Basalt, Cap of Manganese, Mesa, Rawhide Mtns, AZ	113° 42.50' 34° 22.00'	9.6 ± 0.3	KAWR	42
414	Lava(?), North Muddy Mtns, NV	114° 36.00' 36° 30.00'	9.6 ± 3.2	KAHBN	1 (14)
415	Basalt, Manganese Mesa,, Rawhide Mtns, AZ	113° 42.10' 34° 22.00'	9.55± 0.38	KAWR	44 (75-62)
416	Camptonite Dike, Fortification basalt, Hoover Dam, AZ	114° 37.92' 35° 55.42'	9.3 ± 1.1	KACHIL	1 (16-20)
417	Basalt, Buckskin Mtns, AZ	114° 05.60' 34° 13.50'	9.3 ± 0.6		24 (RD-16)
418	Basalt, Peter Kane Mtn, CA	114° 49.92' 33° 03.53'	9 ± 1.8	KAWR	21 (121)
419	Basalt, Pinal Co, AZ	111° 17.15' 33° 05.14'	8.87± 0.26	KAWR	44 (76-89)
420	Basalt, lowest flow, Burro Canyon, AZ	113° 26.40' 34° 32.40'	8.80± 0.36	KAWR	44 (74-82)
421	Basalt, "The Tablelands," Galiuro Mtns, AZ	110° 36.34' 33° 00.96'	8.46± 0.22	KAWR	44 (75-57)
422	Basalt, Burro Canyon, AZ	113° 26.40' 34° 32.40'	8.24± 0.21	KAWR	44 (74-81)
423	Olivine Basalt, within Gila-type gravel, Poston Butte, AZ	111° 24.50' 33° 03.30'	8.12± 0.64	KAWR	44 (72-20)
424	Basalt, in upper Muddy Creek Fm (locally domed by underlying salt movement)	114° 24.42' 36° 24.88'	8	KAWR	21 (124)
425	Basalt, Mogollon Rim, AZ	112° 03.30' 34° 59.90'	7.8 ± 0.3	KAWR	36 (CD6)
426	Basalt, top of Bucket Mtn, AZ	110° 33.99' 33° 19.03'	7.46± 0.59	KAWR	44 (76-130)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
427	Gila Bend Basalt Flow, AZ	112° 53.00' 33° 06.00'	6.5 ± 1.1	KAWR	23 (GB-3,R-2583)
428	Basalt, Perkinsville Fm, AZ	112° 22.47' 34° 58.90'	6.0 ± 0.3	KAWR	36 (PA2)
429	Basalt, Gillespie flow, AZ	112° 46.47' 33° 13.83'	6 ± 1.8	KAWR	21 (97)
430	Basalt, lowermost flow of Fortification Hill sequence	114° 39.60' 36° 02.80'	5.84± 0.18	KAWR	44 (74-138)
431	Basalt, Fortification basalt, Malpais Mesa, AZ	114° 38.33' 35° 49.67'	5.8 ± 1.0	KAWR	1 (21)
432	Volcanic Ash, in basal marl of Bouse Fm, exposed in stream cut approx 1 m below surface, Western Black Mtns	T28N R21W S13	5.74± 1.71	KABIO	24 (RD-1)
433	Basalt, interbedded in Verde Fm, north side of Verde Valley, AZ	111° 54.28' 34° 43.05'	5.5 + 0.2	KAWR	36 (VV1)
434	Vitric Tuff, in basal limestone of Bouse Fm., near Milpitas Wash, CA	114° 52.40' 33° 06.50'	5.47± 0.20	KAWR	44 (69-04)
435	Vitric Tuff, in basal limestone of Bouse Fm, near Milpitas Wash, CA	114° 52.37' 33° 06.48'	5.4	KAGLA	21 (PED-4-69)
436	Basalt, drill chips, Exxon No 1, 3120-3130 m depth	114° 44.00' 32° 29.00'	5.4 ± 1.0	KAWR	44 (74-120)
437	Trachyte (mugearite), volcanic plug, Soda Spring, AZ	110° 32.40' 33° 14.90'	5.28± 0.13	KAANO	44 (75-30)
438	Camptonite Dike, Fortification Basalt, Hoover Dam, AZ	114° 37.92' 35° 55.42'	5.2 ± 0.3	KAKAER	1 (26-20)
439	Crystalline Interior of Basalt, Fortification Basalt, Hoover Dam, AZ	114° 39.42' 35° 56.65'	4.9 ± 0.4	KAWR	1 (15)
440	Basalt, Perkinsville Fm, AZ	112° 07.30' 34° 59.90'	4.8 ± 0.2	KAWR	36 (CD7)
441	Basalt, Perkinsville Fm, near Perkinsville, AZ	112° 12.65' 34° 54.55'	4.7 ± 0.2	KAWR	36 (CD4)
442	Camptonite Dike, Fortification Basalt, Hoover Dam, AZ	114° 37.92' 35° 55.42'	4.6 ± 0.3	KAKAER	1 (16-20)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
443	Vitric Tuff, in Quiburis Fm, AZ	111° 32.87' 32° 39.17'	4.6 ± 0.4	KAGLA	14 (LDA-1-66)
444	Basalt, Perkinsville Fm, NE edge of Chino Valley, AZ	112° 28.20' 34° 52.15'	4.5 ± 0.2	KAWR	36 (PA3)
445	Basalt, Verde Fm, northern end of Verde Valley, AZ	112° 02.75' 34° 49.70'	4.5 ± 0.2	KAWR	36 (CD-2)
446	Basalt, Gila Bend, AZ	112° 53.00' 33° 08.00'	4.5 ± 0.9	KAWR	23 (GB-2,R-2584)
447	Camptonite Dike, Fortification basalt, Hoover Dam, AZ	114° 37.92' 35° 55.42'	4.3 ± 0.1	KAPLA	1 (16-20)
448	Basalt, Gillespie flow, AZ	112° 47.00' 33° 12.00'	4.2 ± 0.4	KAWR	23 (G-13,R-2633)
449	Basalt, Gravel Wash Bay, AZ	114° 01.00' 36° 12.30'	3.80± 0.11	KAWR	44 (65-09)
450	Basalt, Sandy Point, AZ	114° 06.44' 36° 06.54'	3.79± 0.46	KAWR	44 (64-08)
451	Basalt, Gilespie flow, AZ	112° 47.00' 33° 12.00'	3.8 ± 0.4	KAWR	23 (G-15,R-2635)
452	Camptonite Dike, Fortification Basalt, Hoover Dam, AZ	114° 37.92' 35° 55.42'	3.7 ± 0.7	KAWR	1 (16-20)
453	Basalt, Gillespie flow, AZ	112° 47.00' 33° 12.00'	3.5 ± 0.4	KAWR	23 (G-16,R-2636)
454	Basalt, Gillespie flow, AZ	112° 47.00' 33° 12.00'	3.4 ± 0.4	KAWR	23 (G-12,R-2632)
455	Basalt, Gillespie flow, AZ	112° 47.00' 33° 12.00'	3.4 ± 0.4	KAWR	23 (G-14,R-2634)
456	Basalt, Gillespie flow, AZ	112° 47.00' 33° 12.00'	3.3 ± 0.3	KAWR	23 (G-5,R-2637)
457	Basalt, Arlington cone, south summit, AZ	112° 45.60' 33° 19.67'	3.28± 0.27	KAWR	23 (AR-5,73-03)
458	Basalt, Warford Ranch cone, northeastern Sentinal volcanic field, AZ	112° 59.29' 33° 01.10'	3.19± 0.11	KAWR	44 (77-04)
459	Basalt, west side of Arlington flow, AZ	113° 18.08' 32° 56.10'	3.0 ± 0.9	KAWR	21 (106)
460	Basalt, Gillespie flow, AZ	112° 46.96' 33° 14.15'	2.67± 0.20	KAWR	23 (G-8,73-4)

Ertec Location Number	Rock Description and Sample Location	Coordinates	Age in Millions of Years	Dating Method	Reference (Original Spl. No.)
461	Gila Bend Basalt Flow, NW of Gila Bend, AZ	112° 54.00' 33° 09.00'	2.5 ± 0.9	KAWR	23 (GB-1,R-2585)
462	Basalt, Arlington cone, west flow, Arlington, AZ	112° 45.98' 33° 20.96'	2.28± 0.21	KAWR	23 (AR-2,73-151)
463	Basalt, Arlington cone, west flow, Arlington, AZ	112° 43.80' 33° 20.03'	2.17± 0.25	KAWR	23 (AR-6,73-152)
464	Basalt, Arlington cone, west flow, Arlington, AZ	112° 46.14' 33° 20.73'	2.08± 0.18	KAWR	23 (AR-1,73-149)
465	Basalt (Basanite), Dish Hill, near Amboy, CA	115° 56.50' 34° 36.20'	2.03± 0.12	KA	32
466	Basalt, Arlington cone, south summit, Arlington, AZ	112° 44.62' 33° 20.77'	1.92± 0.42	KAWR	23 (AR-4,73-9)
467	Basalt, Midway cone, Sentinal flow, AZ	113° 04.10' 32° 53.40'	1.72± 0.46	KAWR	44 (73-05)
468	Basalt, near summit, Gillespie flow, AZ	112° 48.02' 33° 13.79'	1.35± 0.55	KAWR	23 (G-10,73-7)
469	Basalt, youngest date from Arlington cone, north summit, Arlington, AZ	112° 44.00' 33° 20.00'	1.28± 0.26	KAWR	23 (106)
470	Basalt, Peridot Mesa, AZ	110° 28.12' 33° 20.57'	0.93± 0.08	KAWR	44 (77-33)
471	Alkalic Basalt, Sunshine cone, west of Lavic Lake, CA	116° 22.00' 34° 40.00'	0.138± 0.18	KA	32
472	Alkalic Basalt, Cima Volcanic Field, just north of Kelbaker Road, CA	115° 48.00' 36° 11.00'	330-480 yrs	C^{14} Charcoal	5 (C-22-2)

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APPENDIX A

TABLE A-2

AGES OF ALLUVIAL FORMATIONS

Rock Description and Depth Below Surface	Location	Age	Dating Method	Reference (Original Spl. No.)
Older Alluvial Fan, Q1a, 0.4-0.8 m (Soil Carbonate)	T2N; R22E; NE 1/4, SE 1/4, S 10 (SB)	>300,000	Th - U	4 (49)
Older Alluvial Fan, Q1a, 0-0.1 m (Soil Carbonate)	T2N; R22E; NE 1/4, SE 1/4, S 10 (SB)	131,000 ±12,000	Th - U	4 (PM 5R)
Older Alluvial Fan, Q1a, 0.2 m (Soil Carbonate)	T1N, R24E; NW 1/4, NW 1/4, S 5 (SB)	55,000 ±4,000 or <74,000	Th - U	4 (46)
Older Alluvial Fan, Q1a, 0.75-1 m (Soil Carbonate)	T1N, R24E; SE 1/4, SE 1/4, S 8 (SB)	66,000 ±3,000	Th - U	4 (46)
Older Alluvial Fan, Q1b, 2 m (Soil Carbonate)	T1N, R24E; SE 1/4, SE 1/4, S 8 (SB)	176,000 ±25,000	Th - U	4 (46)
Intermediate Alluvial Fan, Q2a, 0-0.1 m (Soil Carbonate	S Side of Whipple Mtns	>300,000	Th - U	4 (60)
Intermediate Alluvian Fan, Q2a, 0.26-0.35 m (Soil Carbonate)	T1N, R24E; SE 1/4, SE 1/4, S 12 (SB)	46,000 ±4,000	Th - U	4 (31)
Intermediate Alluvial Fan, Q2a, 0.31-0.59 m (Soil Carbonate)	T1N, R23E; SW 1/4, SE 1/4, S 1 (SB)	88,000 ± 10%	Th - U	4 (51)
Intermediate Alluvial Fan, Q2a, 0.30-0.56 m (Soil Carbonate)	T1N R23E; SE 1/4, SE 1/4, S 12 (SB)	80,000 ± 10%	Th - U	4 (52)
Intermediate Alluvial Fan, Q2a, 0.35-0.63 m (Soil Carbonate)	T1N, R23E; SW 1/4, SW 1/4, NE 1/4, S 18 (SB)	76,000 ± 10%	Th - U	4 (53)
Intermediate Alluvial Fan, Q2a, 0.27-0.61 m (Soil Carbonate)	T1N, R24E; SW 1/4, NW 1/4, S 12 (SB)	74,000 ± 10%	Th - U	4 (54)
Intermediate Alluvial Fan, Q2a, 0.35-0.56 m (Soil Carbonate)	T1N, R 23E; NE 1/4, SE 1/4, S 12 (SB)	84,000 ± 10%	Th - U	4 (55)
Intermediate Alluvial Fan, Q2a, 0.42-0.85 m (Soil Carbonate)	T1N, R 23E; SE 1/4, NE 1/4, S 12 (SB)	73,000 ± 10%	Th - U	4 (56)
Intermediate Alluvial Fan, Q2a, 0.39-0.92 m (Soil Carbonate)	T1N, R23E; NW 1/4, SE 1/4, S 1 (SB)	93,000 ± 10%	Th - U	4 (57)

Rock Description and Depth Below Surface	Location	Age	Dating Method	Reference (Original Spl. No.)
Intermediate Alluvial Fan, Q2b, 2 m (Soil Carbonate)	T1N, R24E; SW 1/4, NW 1/4, S 16 (SB)	61,000 ±5,000	Th - U	4 (12)
Intermediate Alluvial Fan, Q2b, 0.2-0.3 m	T1N, R24E; NW 1/4, NW 1/4, S 15 (SB)	20,000-25,000	C^{14}	4 (10)
Younger Alluvial Fan, Q3, 1.3 m	T1N, R24E; NE 1/4, NE 1/4, S 16 (SB)	6,000 ±3,000	Th - U	4 (2)
Younger Alluvial Fan, Q3	T1N, R24E; NE 1/4, NE 1/4, S 16 (SB)	7,000	C_{14}	4 (11)
Intermediate Colorado R. Alluvium, Qrd (Mammoth Tusk)	T4N, R21W; NW 1/4, NW 1/4, NW 1/4, S30 (G+SR)	>40,000	C_{14}	1 (C-2)
Intermediate Colorado R. Alluvium, Qrd (Mammoth Skull)	T1S, R25E; NW 1/4, NW 1/4, NE 1/4; S 5 (SB)	900,000	Amino Acid	1 (AD-1)
Intermediate Colorado R. Alluvium, Qrd (Mammoth Tusk)	T4N, R21W; NW 1/4, NW 1/4, NW 1/4, S 30 (G + SR)	102,000	Amino Acid	1 (AD-2)
Intermediate Colorado R. Alluvium, Qrd (Horse Tooth)	T4N, R21W; NW 1/4, NE 1/4, NW 1/4, S 8 (G+SR)	130,000	Amino Acid	1 (AD-3)
Intermediate Colorado R. Alluvium, Qrd (Vertebrate Bone Fragment)	T4N, R21W; Center on line between NW 1/4 and SW 1/4 of NW 1/4, S 17 (G+SR)	27,500	Amino Acid	1 (AD-4)
Intermediate Colorado R. Alluvium, Qrd (Vertebrate Bone Fragment)	T3N, R22W; NE 1/4, NW 1/4, NW 1/4, S 14 (G+SR)	105,000	Amino Acid	1 (AD-5)
Intermediate Colorado R. Alluvium, Qrd (Vertebrate Bone Fragment)	T4N, R21W; On line between NW 1/4 and SW 1/4, NE 1/4 of NW 1/4 of SW 1/4, S 5, (G+SR)	215,000	Amino Acid	1 (AD-6)
Intermediate Colorado R. Alluvium, Qrd (Vertebrate Bone Fragment)	T4N, R21W; NE 1/4, SE 1/4, S 7 G+SR)	82,500	Amino Acid	1 (AD-7)
Intermediate Colorado R. Alluvium, Qrd (Vertebrate Bone Fragment)	T4N, R21W; On line between Sec. 7+8, NE 1/4, SE 1/4, S 7 (G+SR)	103,500	Amino Acid	1 (AD-8)

Rock Description and Depth Below Surface	Location	Age	Dating Method	Reference (Original Spl. No.)
Older Colorado R. Alluvium QTrb (Caliche)	T8S, R21E; SE 1/4, NE 1/4, NW 1/4, S 30 (SB)	96,000±8,000	Th - U	1 (U-1)
Intermediate Alluvial Fan QFc_2, 0.6 m (Caliche)	T8S, R20E; NE 1/4, NW 1/4, S 25	31,000±3,000	Th - U	1 (U-2)
Intermediate Alluvial Fan Qfc_2, 0.5 m (Caliche)	T8S, R21E; SW 1/4, NW 1/4, S 31 (SB)	61,000±6,000	Th - U	1 (U-3)
Older Alluvial Fan $QTFc_2$ (Caliche)	T9S, R20E; SW 1/4, NW 1/4, NE 1/4, S 14 (SB)	38,000±4,000	Th - U	1 (U-4)
Older Alluvial Fan $QTFc_2$, 0.3 m (Caliche)	T9S, R20E; SW 1/4, NW 1/4, NE 1/4, S 14 (SB)	27,000±4,000	Th - U	1 (U-5)
Older Alluvial Fan $QTFc_2$, 0.2 to 0.6 m (Caliche)	T9S, R20E; SE 1/4, SE 1/4, NW 1/4, S 11 (SB)	125,000±1,400	Th - U	1 (U-6)
Intermediate Colorado R. Alluvium, Qrd (Mammoth Tusk)	T4N, R21W; NW 1/4, NW 1/4, NW 1/4, S 30 (G+SR)	102,000±7,000	Th - U	1 (U-7)
Intermediate Alluvial Fan	T1N, R22E; SE 1/4, NW 1/4, S 15 (SB)	140,000±15,000	Th - U	2 (CS-1)
Intermediate Alluvial Fan	T1N, R22E; SW 1/4, SE 1/4, S 9 (SB)	37,000±8,000	Th - U	2 (CS-2)
Intermediate Alluvial Fan	T1N, R22E; NW 1/4, NW 1/4, S 15 (SB)	98,000±10,000	Th - U	2 (CS-3)
Intermediate Alluvial Van	T1N, R22E; SW 1/4, SW 1/4, S 9 (SB)	39,000±5,000	Th - U	2 (CS-4)
Modern Floodplain Alluvium of Colorado R., 17 m (Carbonized Wood Fragments)	T6N, R23E; SW 1/4, NE 1/4, S 23 (SB)	5,380±300 yrs.	C_{14}	3 (W-11)
Modern Floodplain Alluvium of Colorado R., 105 m (Carbonized Wood Fragments)	T6N, R23E; SE 1/4, NW 1/4, S 11 (SB)	>40,000	C_{14}	3 (W-1142)
Modern Floodplain Alluvium of Colorado R., 20 m (Carbonized Wood Fragments)	T6N, R23E; NE 1/4, SE 1/4, S 24 (SB)	6,250±300 yrs.	C_{14}	3 (W-1501)
Modern Floodplain Alluvium of Colorado R., 34 m (Carbonized Wood Fragments)	T6N, R23E; NE 1/4, SE 1/4, S 24 (SB)	8,610±300 yrs.	C_{14}	3

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