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The non-trivial problem of meteorite pairing

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Abstract–Pairing is the procedure of identifying fragments of a single meteorite fall (that were separated during atmospheric passage or during terrestrial history) by establishing the similarity of two or more meteorite fragments. We argue that pairing is governed by two principles, that only a single mismatch of properties is required to refute a proposed pairing, and that virtually all pairings bear some degree of uncertainty. Using data distributions for modern falls, we take a probability approach to estimate degrees of certainty associated with proposed pairings, emphasizing the importance of unusual features. For new pairing criteria or new analytical additions to old criteria, the degree of variation within individual meteorites must be delineated and the degree of variation within meteorite classes must be quantified. Criteria for pairing can be divided into (1) parent body history indicators, (2) meteoroid space history indicators, and (3) terrestrial history indicators. Included in these categories are 11 specific criteria, including petrographic textures, mineralogy and mineral composition, terrestrial age estimates, cosmic-ray exposure ages, and natural thermoluminescence (TL) levels. Not all criteria are applicable to all meteorite types. About 2275 pairings suggested in the literature have been subjected to this analysis. Many literature pairings, especially those involving common meteorite types, bear large uncertainties due to lack of data.

> *"It turns out that the assigning of different meteorites to the same or to different falls is a non-trivial problem.... The reason for the ambiguity is that similarities are not necessarily proof of a common fall..."* Schultz *et al.* (1991).

INTRODUCTION

"Pairing" is the procedure of identifying fragments of individual meteorite finds from observations made during collection, from their macro- or microscopic properties, or from analytical data. Meteorites fragment during atmospheric passage and during weathering on Earth. Pairing groups can involve three or more samples, sometimes as many as hundreds of fragments. Pairing is not a simple exercise but a challenging endeavor that tests the limits of modern data sets. Here we summarize current ideas concerning pairing with emphasis on degree of certainty, we review suggested literature pairings, and we apply a probability approach to literature pairings. Relating meteorites to common meteoroid bodies (*e.g.*, Wasson *et al.*, 1989; Lipschutz *et al.*, 1989; Benoit and Sears, 1993; Eugster and Michel, 1995; Graf and Marti, 1995) is not considered "pairing" and will not be considered here.

Pairing is important because it can affect the choice of samples for research, but it is of fundamental importance in studies that deal with the statistics of classes or types of meteorites. An example is the debate over if there are changes in the flux of meteorites to Earth that are reflected in differences between Antarctic meteorites and modern falls (*e.g.*, Huss, 1991; Cassidy and Harvey, 1991; Schultz *et al.*, 1991; Wolf and Lipschutz, 1995). Other examples include the delineation of ancient and modern strewn fields (*e.g.*, Kring *et al.*, 1998), studies of factors affecting meteorite preservation (*e.g.*, Jull *et al.*, 1990), and comparisons of meteorite find concentrations (*e.g.*, Huss, 1991; Benoit *et al.*, 1994).

Scott (1984a, 1989) summarized accepted pairing procedures and reviewed proposed pairings of several hundred Antarctic meteorites. Since Scott's work, some pairing procedures have been enhanced, whereas other procedures are now considered less important. In addition, several analytical techniques relevant to pairing, such as ^{14}C terrestrial age estimation, thermoluminescence (TL), and Mössbauer spectroscopy of weathering products have become available and several data bases have been enlarged considerably, especially ^{36}Cl terrestrial ages and cosmogenic noble gas abundances. The last decade has seen the addition of over 10 000 meteorite specimens to the worldwide collection, including thousands more from Antarctica and a growing number from hot deserts, such as North Africa and the Nullarbor Plain of Australia (Sipiera *et al.*, 1987; Bevan and Binns, 1989; Cassidy *et al.*, 1992). The listing of proposed pairings has thus grown considerably.

THE PHILOSOPHY OF PAIRING

The two basic rules of pairing are (1) it is easier to refute a proposed pairing than it is to prove one, and (2) virtually all pairings involve some degree of uncertainty. These rules permeate all pairing efforts, whatever the descriptive or analytical procedures used. Regardless of how many lines of evidence may favor a particular pairing, a single negative line of evidence is generally sufficient to rule out the pairing. Furthermore, refuted pairings generally are not overturned because this requires a radical change in either primary data (a reclassification of a specimen, for example) or in the interpretation of the data, thus completely changing the standards of a pairing criterion. Examples of both are known, but they are rare. The second rule summarizes an important undercurrent of the remainder of our discussion. With the exception of meteorite pieces that physically fit together, like pieces of a puzzle, all potential pairings are subject to some degree of doubt and may potentially be overturned by later evidence. The degree of uncertainty may be very small, as in the case of samples collected in the strewn field of a modern fall shortly after fall (*e.g.*, Begemann *et al.*, 1985). Reducing the uncertainty of a proposed pairing involves the compilation of multiple lines of evidence. However, even the highest quality data and affirmation from all the lines of evidence considered here do not turn a proposed pairing into a certainty. However, it is difficult to express the uncertainty quantitatively. As described below, various procedures can be used to better determine uncertainty, but ultimately pairing is more an art than a science. As a result, uncertainties associated with pairings are often described using quasi-statistical nomenclature (Scott, 1984a), which allow the reader to impose his/her own interpretation.

A Probability Approach

An alternative approach to assessing pairing data is to apply basic probability theory. Starting with any given type of meteorite, the probability of a least one additional member of that class/type (P^+) falling in a set number of meteorites, reflecting a period of time, can be determined.

$$P^+ = 1 - (1 - P_{rel})^n \tag{1}$$

where P_{rel} is the relative abundance of the class/type of meteorite and n is the number of other meteorites under consideration. The meaning of n is further discussed below.

An important part of this approach is the comparison to a "representative" data distribution (P_{rel}). For many pairing criteria, we will use the modern falls as our comparison population. We will assume that meteorite collection and discovery is reasonably inefficient and we will make the common assumption that there have been no significant changes in abundances over time (*e.g.*, Wasson *et al.*, 1989; Cassidy and Harvey, 1991; Benoit and Sears, 1993; Wolf and Lipschutz, 1995).

Equation (1) is based on probability theory described by Arley and Buch (1950), Durran (1970), and others. The present application is a simple case of a series of Bernouilli trials in which either a meteorite sample is the same as another or it is not. Equation (1) is therefore an expression of the binomial law, which states that in a Bernouilli experiment the probability of an event occurring r times out of v trials (P_r) is:

$$P_r = \theta^r (1-\theta)^{v-r} \tag{2}$$

where θ is the probability of the event occurring per trial. In the present analysis, we assume that each trial is independent and occurs with replacement; that is, that each trial does not significantly change θ for subsequent trials. Equation (1) is the expression of this equation if $v = r$; that is, that each event in v trials will be the same. In effect, we calculate the probability that all the meteorites in v falls will be different from the sample of interest. Because our statistics (Table 1, *etc.*) are for the probability of similarity (P_{sim}), we convert these to the probability of difference, so $\theta = (1 - P_{sim})$. To reconvert the result to express likelihood of similarity, we must subtract it from unity. The same result could be obtained by calculating directly using P_{sim}, but this would require solving an integral for the probability of all possible combinations of events (*e.g.*, that 1, 2, 3,... meteorites in the group will match the first).

Table 1 shows the likelihood of one or more of nine meteorites will be of the same chemical class and type as the first meteorite sampled. It is apparent that the likelihood of a "false pairing," or pairing an independent meteorite of the same type and class with the first meteorite, can be significant for the more common types of meteorites. This likelihood can be reduced by making additional comparisons, modifying P_{rel}:

$$P_{rel} = P_{rel*} \times P_x \times P_y \tag{3}$$

where P_{rel*} is the probability of occurrence from Table 1, and P_x and P_y represent the probability of occurrence in comparison data sets X and Y. Equation (3) is an expression of the definition of probabilistic independence (*e.g.*, Durran, 1970). If A and B are independent events (*i.e.*, the occurrence of A does not influence the occurrence of B), then the probability of both occurring together (P_{AB}) is:

$$P_{AB} = P_A \times P_B \tag{4}$$

TABLE 1. Number and relative abundance of observed falls, by classification.

Classification	Number	Abundance (%)	Probability, at least one out of nine*
ANGR	1	0.1	1.0
AUB	9	1.0	8.7
AURE	5	0.6	4.9
CI	5	0.6	4.9
CK	1	0.1	1.0
CM	13	1.5	12.3
CO	5	0.6	4.9
CR	3	0.3	3.0
CV	6	0.7	5.9
EH	8	0.9	7.8
EL	7	0.8	6.8
H	305	34.0	97.6
Type 3	–	1.5	12.3
Type 4	–	5.4	39.1
Type 5	–	15.0	76.7
Type 6	–	9.6	59.7
H/L	1	0.1	1.0
L	340	37.9	98.6
Type 3	–	1.0	8.7
Type 4	–	2.1	17.5
Type 5	–	7.0	48.1
Type 6	–	26.0	93.3
L/LL	8	0.9	7.8
LL	73	8.1	53.5
Type 3	–	1.2	10.5
Type 4	–	1.0	8.7
Type 5	–	1.9	15.8
Type 6	–	3.7	28.7
R	1	0.1	1.0
HED	52	5.8	41.6
MES	7	0.8	6.8
SNC	4	0.4	3.9
IAB	6	0.7	5.9
IID	2	0.2	2.0
IIE	1	0.1	1.0
IIF	1	0.1	1.0
IIAB	8	0.9	7.8
IIIAB	6	0.7	5.9
IRUNGR	7	0.8	6.8
IVA	4	0.4	3.9
PAL	4	0.4	3.9

Abbreviations: ANGR = angrites; AUB = aubrites; AURE = ureilites; HED = howardites/eucrites/diogenites; MES = mesosiderites; SNC = "martian"; IRUNGR = iron, ungrouped; PAL = pallasites.
*Probability that at least one out of nine samples in a random selection of meteorites will be of the same classification and type.

An important aspect of this approach is the importance of independent data comparisons to strengthen proposed pairings. In the next section, we discuss various pairing criteria in this context. Using this approach, one can assess either the relative strength or the true likelihood of a proposed pairing. If we wish to assess the true likelihood, we must determine the true number of meteorites (n in Eq. 1) in the fall locality, but this number is rarely known with certainty. A small n (1–3) is appropriate for the strewn field of a modern fall, but n is considerably larger for desert accumulation surfaces. For meteorite finds, the value of n could be approximated for each collection site using the total number of meteorites recovered at the site and reducing the number as pairings are proposed. Tens to thousands of meteorites have been found on collection sites in Antarctica, North Africa, Australia, and the deserts of the western United States. The determination of true likelihood, although more rigorous, is thus subject to uncertainties on the true value of n and must be altered as new pairings are proposed and possibly as more meteorites are found at a given site. It may also be altered if the comparison statistics are altered by inclusion of new data. An alternative approach is to calculate relative pairing likelihood, using an arbitrary value of n. Although not as rigorous, this approach is useful to emphasize pairing strengths between individual meteorites, and the calculated likelihoods are less likely to be altered by later events. In the present analysis, we will only assess relative pairing likelihood.

Pairing Criteria

Classification data are the primary basis for a pairing analysis. The usefulness of any other property depends largely on the variability of the property within meteorite classes relative to the expected degree of variation in multiple samples of individual meteorites (Table 2). However, the internal heterogeneity of many properties is poorly documented, as will be discussed here for some pairing criteria, and discussed in greater detail in the literature. Second, some analytical or descriptive techniques are not universally applicable (*e.g.*, TL measurements are not possible on iron meteorites) (Table 3). Finally, some analytical or descriptive data are related and thus do not provide independent evidence. For example, TL sensitivity, Mössbauer spectroscopy, and petrographic weathering classifications for equilibrated ordinary chondrites might appear independent but are all heavily influenced by weathering (Table 4).

The ten major pairing criteria can be divided into three categories described in Table 2. Not all the criteria are listed for each major meteorite classification in Table 3. The absence of a particular criterion means that there are insufficient data currently available to allow assessment. Even if a criterion is not sufficiently developed to confirm pairings, it can be used to refute pairings if there is a significant difference between two specimens. Likewise, the placement of some data as "supportive" (*e.g.*, cosmogenic noble gas abundance data for enstatite chondrites) often reflects the scarcity of data and/or the small number of meteorites available.

TABLE 2. Classes of possible pairing criteria.

Parent body history indicators
Bulk composition, isotopic concentrations, formation ages
Mineral abundance and compositions
Petrographic textures (shock/metamorphism/igneous)
Stable isotope composition and formation ages

Meteoroid space history indicators
Cosmogenic noble gas ratios/abundances (cosmic-ray exposure age, shielding, solar gases, thermal history) and natural TL (reheating).

Meteorite terrestrial history indicators
Proximity
Shape and Size
Number of specimens/size of pairing group
Terrestrial age
Degree of weathering
Natural thermoluminescence (recent thermal/radiation history)

Bulk Elemental and Isotopic Concentrations–Bulk composition has proven to be a good tool for the chemical classification of meteorites partly because the major groups generally display a very limited range of compositions. However, this makes bulk composition of little value in pairing. Differences in H_2O content and in the abundance of some elements, notably Au, Cl, Co, Cs, I, Se, Ga, Rb, Cs, Te, Bi, In, Ag, Zn, Tl, and Cd, and in the abundance of $Fe_{(metal)}$ relative to Fe_2O_3, are generally attributed to weathering or shock (Biswas *et al.*, 1980; Neal *et al.*, 1981; Walsh and Lipschutz, 1984; Dreibus *et al.*, 1986; Jarosewich, 1990; Nobuyoshi *et al.*, 1997), which we will discuss elsewhere. However, covariation in Bi, Co, In, Sb, Cs, and Tl, has been suggested as a method of identifying subgroups in the H chondrites that could be used as a basis for pairing (Dennison and Lipschutz, 1987; Wolf and Lipschutz, 1995). Carbon abundance varies significantly within the unequilibrated ordinary chondrites such that it can be used as a taxonomic and pairing tool (Grady *et al.*, 1989; Sears *et al.*, 1991a). Bulk composition, notably the abundance of Ir, the rare earth elements, and the abundance of moderately volatile elements Zn, Se, As, Ga, and Au have been used for pairing in the carbonaceous chondrites (Bischoff *et al.*, 1993). The lack of "clumping" in trace element data for eucrites from Antarctica has been used as an argument against extensive pairing in that collection (Paul and Lipschutz, 1990). Iron meteorites exhibit significant variation within subclasses, compared to variation within individual meteorites (Buchwald, 1975; Malvin *et al.*, 1984). Pairing for iron meteorites typically involves noting close similarity on plots of Ga, Ge, Co, Cu, As, Au, W, Ir, and possibly Tl against Ni, with differences greater than ~10% in any element being considered evidence against pairing, although a slightly greater difference in one or perhaps two elements may be acceptable (Malvin *et al.*, 1984; Wasson *et al.*, 1989; Guo *et al.*, 1994).

One potential problem in using bulk composition data for pairing is that the database is highly segmented. Bulk compositional data can be obtained using x-ray fluorescence, atomic absorption, instrumental and radiochemical neutron activation analysis, as well as classical wet chemical methods. Electron microprobes have been used in this application as well, using "broad" electron beams or by calculation from modal data and point compositions, but only major elements and some of the more prominent minor elements are typically measured, and the data obtained in this fashion are subject to many uncertainties (Warren, 1997). The choice of method(s) depends on the amount of sample and the instrumentation available, and also on the emphasis of the study (trace element *vs.* major). Ideally data from different research groups can be compared regardless of instrumentation. In practice, caution must be exercised in comparing data, because different techniques have different potential analytical problems that might influence the data. At a minimum, before comparison, it is necessary to compare analyses of appropriate meteoritic standards, such as Allende (Jarosewich, 1990).

Stable Isotope Abundance and Formation Ages–Bulk sample stable isotope abundance or ratios might be used for pairing, but the heterogeneity of most isotopes within and between meteorites is largely unknown. The O-isotopic system is the best studied. Oxygen-isotopic ratios are too homogeneous within major meteorite classes for pairing applications, although they could potentially be used as an indicator for degree of weathering for ordinary chondrites (Clayton *et al.*, 1976, 1983; Clayton and Mayeda, 1983; Clayton, 1991). The relative isotopic abundance of radioactive decay products are also potentially useful. The abundance of Ar isotopes (Ar-Ar ages) reflects thermal history and thus can be used to support pairings, although these data may be influenced by weathering (Bogard and Garrison, 1999). The Re-Os ages might also be used to support pairings, although the current database is small (Walker *et al.*, 1999).

Mineral/component Abundance and Compositions–Of course, the modal abundance of major minerals is dependent on major element bulk composition (Table 4), because these parameters are related. The modal abundances of minerals and meteorite components (chondrules, matrix, metal, sulfides, clasts, calcium-aluminum-rich inclusions (CAIs),...) can be measured by manual point counting (*e.g.,* McSween, 1979; Grossman *et al.*, 1988; Scott, 1988; Zhang *et al.*, 1995) or by automatic methods using an electron microscope or an optical microscope (*e.g.*, Conway and Bland, 1998).

Although the abundance of minerals is usually mentioned during petrographic description, quantitative data are rare and it is difficult to formulate quantitative criteria for pairing decisions. The greater availability of computer-based automated microscopy is likely to change this situation in the future (Conway and Bland, 1998). An arbitrary criterion might be established requiring that paired fragments agree in modal abundance within 5%. Although this may not adequately allow for heterogeneity within meteorites and it may be influenced by grain size, it provides a conservative criterion for pairing. Large grains of particular minerals, or large fragments of chondrules, metal grains, clasts, and CAIs, and perhaps other components may have a significant effect on statistics based on a single thin section, and statistics should be based on at least two thin sections.

The relative abundances of various types of refractory inclusions can serve as a pairing criterion (MacPherson *et al.*, 1988; Rubin, 1998), as can the abundance and type of oxide inclusions in iron meteorites (Wasson *et al.*, 1989). The relative abundance of chondrule types, identified petrographically or by cathodoluminescence, can serve as a guide to pairing of unequilibrated ordinary chondrites and the carbonaceous chondrites (*e.g.*, Grossman *et al.*, 1988; Sears *et al.*, 1995), and xenolithic clast populations (Bunch and Rajan, 1988) could also be used. The size and shape distributions of chondrules may also exhibit sufficient variation for pairing purposes, especially for carbonaceous chondrites (Hughes, 1978; King and King, 1978, 1979; Grossman *et al.*, 1988; Rubin, 1998). However, the heterogeneity of these properties within a meteorite and the expected degree of variation within meteorite classes is presently not well known.

The abundance of accessory minerals can also be used as a criterion for pairing and can be considered independent of bulk composition and major mineral abundance. A list of potential minerals was published by Rubin (1997), but its utility is limited by lack of knowledge about the expected degree of variation within meteorites. The abundance of feldspar in unequilibrated ordinary chondrites and CO and CV chondrites can be measured using TL sensitivity, which displays minimal variation within meteorites but several orders of magnitude variation between meteorites (Keck and Sears, 1987; Sears *et al.*, 1991a; Guimon *et al.*, 1995). The abundance of eucritic material in howardites can also be measured using TL sensitivity, exhibiting about an order of magnitude variation between meteorites (Batchelor and Sears, 1991). Minerals produced by shock events or weathering are considered below.

TABLE 3. Ranking of criteria for pairing in meteorite groups.

Iron meteorites	Carbonaceous chondrites	Enstatite chondrites	Unequilibrated ordinary chondrites	Ordinary chondrites	Achondrites	Lunar meteorites	SNC
Primary							
Bulk composition Mineral abundance and composition Metallographic texture Rarity	Mineral abundance and composition Rarity Petrographic texture	Mineral abundance and composition Rarity Petrographic texture	Petrographic texture Natural TL Degree of weathering Mineral abundance and composition Bulk composition Terrestrial age	Natural TL Cosmogenic noble gases Terrestrial age Degree of weathering	Mineral abundance and composition Petrographic texture Cosmogenic noble gases	Mineral abundance and composition Petrographic texture Rarity	Mineral abundance and composition Petrographic texture Rarity
Secondary/supportive							
Degree of weathering Cosmogenic noble gas Terrestrial age	Cosmogenic noble gas Terrestrial age	Cosmogenic noble gases Terrestrial age Natural TL	Rarity	Petrographic texture Mineral abundance and composition	Natural TL Degree of weathering Terrestrial age	Cosmogenic noble gases Terrestrial age Natural TL	Terrestrial age
Not useful							
Natural TL				Bulk composition*			

*Possible exception: Antarctic H chondrites (Dennison and Lipschutz, 1987).

Table 4. Interdependent pairing criteria.

Meteorite class	Interdependent criteria
Carbonaceous chondrites	Major element composition/modal mineralogy Component abundance/induced TL
Enstatite chondrites	Major element composition/modal mineralogy Mineral composition/induced TL
Unequlibrated ordinary chondrites	Major element composition/modal mineralogy Weathering class/Mössbauer/noble gas ratios Solar noble gas abundance/brecciation
Equilibrated ordinary chondrites	Major element composition/modal mineralogy Weathering class/Induced TL/Mössbauer/noble gas ratios Solar noble gas abundance/brecciation
Achondrites	Major element composition/modal mineralogy
Iron meteorites	Major element composition/modal metallography

Mineral composition is usually determined by electron microprobe analysis of minerals in a polished thin section and is a primary pairing tool for all meteorites except equilibrated ordinary chondrites. The degree of Mg-Fe heterogeneity in olivine grains is useful for subclassification of unequilibrated ordinary chondrites (Sears *et al.*, 1991a), and the degree of Mg-Fe and Fe-Ca zoning in pyroxene grains varies significantly among eucrites (Takeda *et al.*, 1983; Batchelor and Sears, 1991). Lunar meteorites (and lunar samples) exhibit a wide compositional range in olivine, pyroxene, and plagioclase (Yanai and Kojima, 1991), and the Shergotty–Nakhla–Chassigny (SNC) meteorites exhibit considerable variation in pyroxene composition (McSween, 1994). The composition of olivine and the Fe/Ni ratio of metal is diagnostic for carbonaceous chondrites (*e.g.*, Bischoff *et al.*, 1993). The relative homogeneity compared to other meteorite groups and the limited amount of data on heterogeneity within individual meteorites prevents common application of mineral composition data for the pairing of equilibrated ordinary chondrites, but there is sufficient variation for these data to be supportive in some cases (*e.g.*, Scott *et al.*, 1986a; Rubin, 1990).

Petrographic Texture–Primary textures include those attributed to igneous and metamorphic processing. Among iron and lunar meteorites, SNC meteorites, and achondrites, these include cumulate textures, interstitial textures, and partial melting textures. Among the chondrites, textures include progressive coarsening of matrix grain size, formation of 120° mineral junctions, and the loss of definition of chondrules and clasts. In most meteorite classes, these textures have been used to define subclassifications (*e.g.*, petrologic types) within major chemical groups (Van Schmus and Wood, 1967). These are extensively described in the literature and are not repeated here. However, they are an extremely important pairing criterion and, with the exceptions of polymict breccias, paired fragments should exhibit the same primary textures.

Secondary textures are inferred to have been produced by shock processing. Mineral grains exhibit a range of effects, from undulatory extinction to recrystallization textures. On the macroscopic level, opaque shock veins and melt pockets may be visible. Similarly, secondary textures have been used to define levels of processing, or shock stages, for most of the major meteorite groups (Table 5; Stöffler *et al.*, 1991; Scott *et al.*, 1992; Rubin *et al.*, 1997). Shock classifications from the system of Dodd and Jarosewich (1979) cannot be converted to the current system. In practice, paired specimens should be of the same shock classification or differ by no more than one stage.

An additional "textural" criterion is brecciation, which can occur on both the micro and macro level. Gas-rich regolith breccias show the light–dark structure and the presence of "foreign" clasts, such as CM clasts in an H chondrite, can also characterize some meteorites (Binns, 1967; Keil, 1982; Bunch and Rajan, 1988). However, brecciation as a pairing guide is limited by the fairly common occurrence of brecciation textures (Table 6), the unknown degree of

TABLE 5. Abundance of shock stages for various classes and petrologic types of observed falls.

Class/type	S1	S2	S3	S4	S5	S6
CM2	100.0	0.0	0.0	0.0	0.0	0.0
CO3	80.0	0.0	20.0	0.0	0.0	0.0
CV3	60.0	0.0	40.0	0.0	0.0	0.0
EH	0.0	25.0	75.0	0.0	0.0	0.0
EL6	0.0	100.0	0.0	0.0	0.0	0.0
H3	25.0	25.0	25.0	0.0	25.0	0.0
H4	8.3	33.3	58.3	0.0	0.0	0.0
H5	4.5	18.2	54.5	18.2	0.0	4.5
H6	17.6	11.8	52.9	11.8	0.0	5.9
L3	0.0	0.0	60.0	40.0	0.0	0.0
L4	11.1	22.2	55.6	11.1	0.0	0.0
L5	0.0	20.0	60.0	6.7	13.3	0.0
L6	0.0	4.0	44.0	32.0	12.0	8.0
LL3	16.7	33.3	33.3	16.7	0.0	0.0
LL4	0.0	0.0	100.0	0.0	0.0	0.0
LL5	11.1	44.4	33.3	11.1	0.0	0.0
LL6	0.0	0.0	85.7	0.0	0.0	14.3

Data from Stöffler *et al.* (1991), Scott *et al.* (1992), and Rubin *et al.* (1997).

TABLE 6. Minimum abundance of brecciated meteorites in major meteorite classes and types.*

Class/type	*n*	Abundance (%)
AUB	9	56
CM	13	15
CV	6	17
EH	8	38
EL	7	29
EUC	28	79
HOW	15	100
H3	13	31
L3	9	56
LL3	11	45
H4	46	24
H5	136	18
H6	88	14
L4	20	30
L5	63	22
L6	236	8
LL4	9	22
LL5	17	53
LL6	33	45

*Based on observed falls.
Abbreviations: AUB = aubrite; EUC = eucrite; HOW = howardite.
Data from the compilation of Koblitz (1997).

heterogeneity in the thin sections and hand specimens, and the rarity of xenolithic clasts.

Cosmogenic Noble Gases–The abundance of noble gases produced by galactic cosmic rays has commonly been applied to pairing (*e.g.*, Schultz *et al.*, 1991; Scherer *et al.*, 1998). The largest databases are limited to isotopes of He, Ne, and Ar (*e.g.*, Schultz and Kruse, 1989). The data provide two independent pairing criteria, cosmic-ray exposure age and meteoroid size. Two additional criteria that are useful in rare cases are unusual thermal histories and regolith history (Schultz *et al.*, 1991).

Cosmic-ray exposure ages are commonly calculated from ^{3}He, ^{21}Ne, and ^{38}Ar abundance (*e.g.*, Eugster, 1988; Schultz *et al.*, 1991; Graf and Marti, 1995). Paired meteorites should have similar cosmic-ray exposure ages that agree within the experimental uncertainties of ~10%.

Meteoroid size can be an effective pairing indicator because shielding produces marked differences in ^{3}He/^{21}Ne and ^{22}Ne/^{21}Ne ratios in ordinary chondrites; samples from a single meteorite always fall along a positive trend line (Schultz *et al.*, 1991). Samples exhibiting a negative trend are not likely to be paired. This method may not be applicable to all major meteorite groups (*e.g.*, Eugster and Michel, 1995).

High abundances of solar gases, notably ^{4}He and ^{20}Ne, are indicative of long duration exposure on the surface of the parent body. Heterogeneity of solar gas contents within meteorites can be very large, but gas-rich meteorites are sufficiently rare that this is not a problem. Unusual thermal histories such as meteorites heated by close solar passage or intense shock result in the preferential loss of the light noble gases, and lower ^{3}He/^{21}Ne ratios than expected from ^{3}He/^{21}Ne *vs.* ^{22}Ne/^{21}Ne plots, or by calculated ^{3}He cosmic-ray exposure ages being significantly lower than those calculated from ^{21}Ne or ^{38}Ar. The relative abundances of meteorites exhibiting these features are noted in Table 7.

TABLE 7. Likelihood of occurrence of cosmic-ray exposure age for H, L, and LL chondrites, eucrites, and howardites.

Cosmic-ray exposure age (Ma)	H chondrites (*n* = 301)	L chondrites (*n* = 213)	LL chondrites (*n* = 50)	Eucrites (*n* = 26)	Howardites (*n* = 17)
<1.0	1.7	0.5	0.0	0.0	0.0
1.0–1.3	0.7	0.0	2.0	0.0	0.0
1.3–1.6	0.7	0.5	0.0	0.0	0.0
1.6–2.0	1.3	0.0	0.0	0.0	0.0
2.0–2.5	0.7	1.9	0.0	0.0	0.0
2.5–3.2	3.0	3.8	2.0	3.8	0.0
3.2–4.0	2.7	0.5	0.0	0.0	0.0
4.0–5.0	6.0	4.2	2.0	3.8	0.0
5.0–6.3	11.0	7.0	2.0	0.0	0.0
6.3–7.9	22.6	0.5	6.0	7.7	0.0
7.9–10.0	11.0	6.6	8.0	11.5	0.0
10.0–12.6	4.0	7.0	12.0	7.7	5.9
12.6–15.8	4.7	9.4	26.0	3.8	0.0
15.8–20.0	3.7	8.0	8.0	15.4	23.5
20.0–25.1	7.6	16.4	4.0	11.5	29.4
25.1–31.6	4.3	12.7	10.0	15.4	0.0
31.6–39.8	8.6	1.9	6.0	7.7	23.5
39.8–50.1	2.0	16.0	8.0	11.5	11.8
50.1–63.1	2.0	2.8	2.0	0.0	0.0
63.1–79.4	2.0	0.5	2.0	0.0	5.9
>79.4	0.0	0.0	0.0	0.0	0.0
Solar-gas rich	12.6	–	6.0	–	–
^{3}He depleted	–	–	–	69.2	17.6

Data from compilations of Graf and Marti (1994, 1995), Marti and Graf (1992), and Eugster and Michel (1995).

Geographic Proximity–Strewn fields can be up to 100 km or so in length and tens of kilometers in width (*e.g.*, Allende: Clarke *et al.*, 1970; Gibeon: Buchwald, 1975; Jilin: Begemann *et al.*, 1985; Gold Basin: Kring *et al.*, 1998; Guenie: Bourot-Denise *et al.*, 1998); normally they are <10 km in maximum dimension (*e.g.*, Mbale: Jenniskens *et al.*, 1994; Juan Cheng: Chen *et al.*, 1998; St. Robert: Brown *et al.*, 1996; Leedey, Oklahoma: McCoy *et al.*, 1997; Portales, New Mexico: Povenmire and Wilson, 1999). However, in some environments (like Antarctica), it is likely that meteorite fragments, especially small (<50 g) fragments, can be dispersed by wind, water, and ice movement (Cassidy *et al.*, 1992).

In current pairing practice, proximity is typically regarded only as supportive of pairing and is rarely cited as a primary criterion (Marvin, 1989; Scott, 1989). In the Allan Hills and Lewis Cliff regions of Antarctica, for example, potentially paired fragments identified by petrographic and TL data were typically found only a few kilometers apart (Scott, 1989; Benoit *et al.*, 1992, 1993a). Similar pairing groups were present at the Pecora Escarpment (Fig. 1). In the Elephant Moraine region, however, potentially paired fragments were found to be widely dispersed (Benoit *et al.*, 1994), and in hot deserts paired fragments were separated by tens of kilometers (Jull *et al.*, 1990).

We do not recommend a specific proximity criterion for pairing, but pairing fragments separated by more than 50 to 100 km should be reserved for special cases.

Shape and Size–External morphology and color of meteorite have been used as evidence for pairing. The most prominent feature of external morphology is the fusion crust (Nininger, 1936; Sears, 1974), the similarity in coverage, texture, and color sometimes being used to support pairings (Cassidy, 1980). Also of value is the degree of ablational rounding of the samples. This type of analysis is nondestructive and requires minimal equipment (*e.g.*, Clarke *et al.*, 1980; Score *et al.*, 1982). However, the data are subjective and thus difficult to apply to pairing within large groups of meteorites. Among meteorite finds, fusion crust is often partially or completely destroyed by weathering. For these reasons, we suggest that use of exterior descriptions should be limited to rare classes and should be considered as suggestive of pairing rather than as definite. Abundance of rust and other weathering products are considered separately below.

Number of Specimens/Size of Pairing Group–If an unusually high proportion of meteorites of the same class or type are found in one region, they are probably paired. The argument is based on the fragmentation behavior of meteorites, large "showers" being rare among modern falls (Fig. 2).

The overabundance of a particular type of meteorite class or type compared to modern falls suggests a likely pairing, although it cannot be used to specify relationships of individual fragments (*e.g.*, Huss, 1991; Ikeda and Kimura, 1992). Relative abundance is already incorporated in our "rarity" criterion, described above.

Terrestrial Age–The length of time a meteorite has been on Earth can be estimated from the abundance of cosmogenic radionuclides such as ^{14}C, ^{26}Al, ^{36}Cl, and ^{81}Kr (Nishiizumi *et al.*, 1989) and, in the case of hot desert finds, from natural TL (Benoit *et al.*, 1993b).

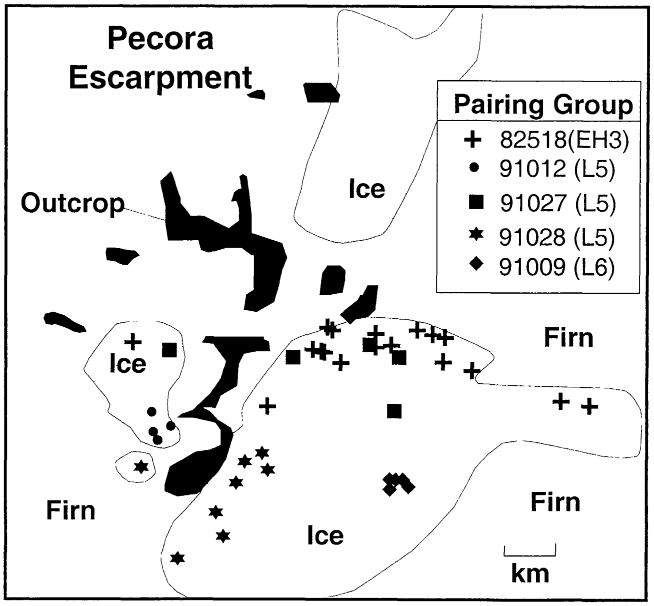

FIG. 1. Geographic distribution of possible pairing groups at the Pecora Escarpment, Antarctica. Pairing groups were delineated using TL data without regard to proximity, but paired fragments are found in close proximity or along linear trends.

Half-lives and uncertainties in preterrestrial saturation activities impose constraints on the quality of terrestrial age estimates. Radiocarbon ($t_{½}$ = 5320 years) can be used to estimate terrestrial ages <40 000 years (Jull *et al.*, 1990), whereas ^{36}Cl ($t_{½}$ = 301 000 years) enables terrestrial age estimates for meteorites that have been on Earth for up to several million years, but ages <150 000 years cannot be determined and uncertainties are typically tens of thousands of years (Nishiizumi *et al.*, 1989). The 705 000 year half-life of ^{26}Al severely limits its utility, the maximum known terrestrial age for an Antarctic meteorite being ~1.5 Ma (Welten *et al.*, 1997).

For pairing, meteorites should have the same terrestrial age within the uncertainties of the method. An estimate of the distribution for Antarctic meteorites is given in Table 8. However, this should be done with caution because the distribution is derived from a small number of samples and includes a broad diversity of meteorite types including carbonaceous and achondrites and may be influenced by unidentified pairings (Jull *et al.*, 1998). Approximations of terrestrial age distributions for meteorites from the western United States, the Sahara, and Australia are also available (Jull *et al.*, 1990, 1993, 1995), but these are based on even smaller numbers of samples.

Degree of Weathering–Weathering results in the destruction of metal and sulfides and the production of iron oxides and hydroxides and, in some cases, evaporites. These changes are reflected in changes in bulk composition; H_2O is introduced and the abundance of Au, Cl, Co, Cs, I, Se, Ga, Rb, Cs, Te, Bi, In, Ag, Zn, Tl, and Cd, are affected (Biswas *et al.*, 1980; Neal *et al.*, 1981; Walsh and Lipschutz, 1984; Dreibus *et al.*, 1986; Jarosewich, 1990; Nobuyoshi *et al.*, 1997). Nitrogen and H contents may be significantly depleted in weathered carbonaceous chondrites in hot deserts and C contents tend to be more heterogeneous in the meteorites compared to modern falls (Ash and Pillinger, 1995). Although these data can be used to support potential pairings, the database is not currently sufficient to allow quantitative evaluations. The modal abundance of weathering products in thin sections can sometimes also be used to support or refute pairings (McCoy *et al.*, 1995; Fig. 3).

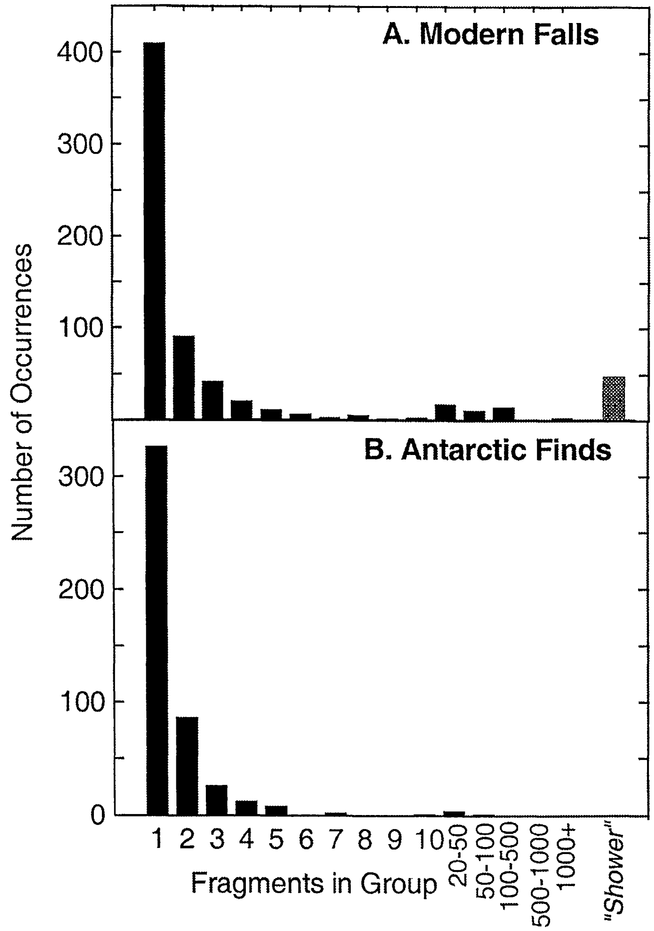

FIG. 2. Fragmentation of (a) modern falls and (b) Antarctic meteorites. The number of pieces noted for modern falls is taken from historical records (referenced in Koblitz, 1997). "Shower" refers to cases where the exact number of fragments was not noted in the historical records but is likely to be in excess of 10 fragments. Fragmentation of Antarctic meteorites is based on study of 662 ordinary chondrite samples, the size of pairing groups suggested from TL data (Benoit *et al.*, 1992, 1993a, 1994).

The degree of weathering can be assessed from the condition of fusion crust, the amount of "rust," and the presence of evaporites (*e.g.*, Grossman and Score, 1996). These data are widely available for Antarctic meteorites (Table 9), but the procedure is subjective and imposes categories on gradational data. Thus, meteorites in adjacent weathering classes could be paired. A weathering classification system based on the alteration of metal and sulfide grains as they appear in polished section has also been proposed but has only been applied widely to meteorites from North Africa (Wlotzka, 1993; Table 10). There is no simple relationship between weathering classes based on the exterior description and those based on the petrography of the metal and sulfide.

Mössbauer spectroscopy can be used to quantify the abundance of iron-oxide weathering products (Burns *et al.*, 1995). The Mössbauer spectroscopy database is currently being developed (Bland *et al.*, 1996), but multiple samples taken from individual meteorites from hot and cold deserts show good agreement (Fig. 4). These data indicate that paired samples should agree within 10%,

TABLE 8. Likelihood of occurrence of Antarctic meteorites* of specific terrestrial ages.†

Terrestrial age (10^3 years)	Abundance (%) (n = 82)
0–30	8.5
31–60	30.5
61–90	9.8
91–120	6.1
121–150	4.9
151–180	3.7
181–210	6.1
211–240	6.1
241–270	7.3
271–300	0.0
301–330	4.9
331–360	2.4
361–390	1.2
391–420	0.0
421–450	0.0
451–480	0.0
481–510	1.2
411–540	3.7
451–570	0.0
571–600	2.4
601–630	0.0
631–660	0.0
661–690	0.0
691–720	0.0
721–750	1.2
751–780	0.0
891–810	0.0
811–840	0.0
841–870	0.0

*Mostly ordinary chondrites.
†Calculated from ^{14}C, ^{36}Cl, and ^{81}Kr activity.
Data from Nishiizumi *et al.* (1989), Michlovich *et al.* (1995), and Jull *et al.* (1998).

TABLE 9. Distribution of weathering classes estimated from exterior appearance for Antarctic meteorites.

Class/Type		Weathering Class				
	n	A	A/B	B	B/C	C
Unequilibrated						
H3	72	8.3	12.5	37.5	23.6	18.1
L3	183	3.8	8.2	32.2	25.7	30.1
LL3	32	9.4	6.3	34.4	28.1	21.9
Equilibrated						
H4	358	3.6	2.8	45.3	23.7	24.6
H5	1993	0.2	4.5	21.7	37.0	36.5
H6	983	1.1	3.5	20.2	40.4	34.8
L4	140	2.1	14.3	38.6	27.1	17.9
L5	826	2.7	34.0	40.1	19.2	4.0
L6	2480	3.8	21.3	43.3	22.3	9.3
LL4	17	11.8	17.6	35.3	17.6	17.6
LL5	54	3.7	20.4	37.0	18.5	20.4
LL6	218	20.2	33.9	27.1	11.9	6.9

Data are not corrected for possible pairings and are taken from the compilations of Grossman (1994) and Grossman and Score (1996).

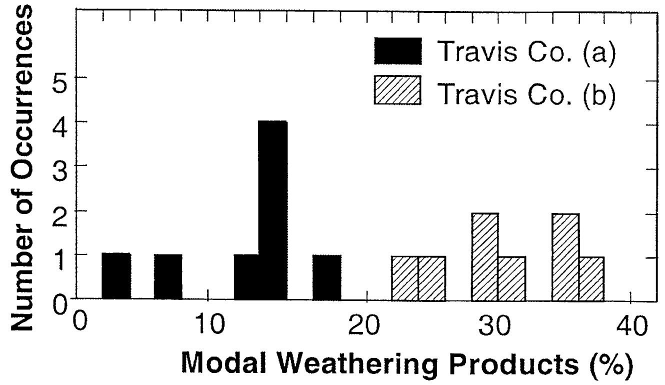

FIG. 3. Modal abundance of weathering products in samples of two weathered meteorites from Travis County, Texas. The difference in modal abundance of weathering products was used by McCoy *et al.* (1995) to refute pairing of Travis (a) and Travis (b). Note, however, the significant degree of heterogeneity within each meteorite.

TABLE 10. Abundance of Saharan meteorites in weathering classes, by class and type.*

Class/type	*n*	W0/W1	W1	W2	W3	W4
Unequilibrated						
H3	21	4.8	23.8	57.1	9.5	4.8
L3	7	0.0	28.6	28.6	28.6	14.3
Equilibrated						
H4	29	0.0	13.8	51.7	27.6	6.9
H5	80	5.0	12.5	45.0	26.3	11.3
H6	31	12.9	25.8	32.3	25.8	3.2
L4	6	16.7	0.0	83.3	0.0	0.0
L5	25	16.0	16.0	32.0	12.0	24.0
L6	56	0.0	8.9	41.1	33.9	16.1
LL4,5,6	23	0.0	8.7	60.9	21.7	8.7
All equilibrated	250	5.2	13.2	44.4	25.6	11.6

*Potentially paired samples have been removed and the weathering classification system of Wlotzka (1993) is used.
Data from Bischoff and Geiger (1995).

although greater variation is expected within 1 cm of the surface (Bland *et al.*, 1995). The abundance of oxidized Fe species from Mössbauer spectroscopy is shown in Fig. 5 and listed in Table 11.

Thermoluminescence sensitivity also reflects weathering in equilibrated ordinary chondrite finds (Benoit *et al.*, 1991) and exhibits limited heterogeneity within samples (generally no more than a factor of 2) and significant differences between meteorites can be observed (Fig. 6). Table 12 summarizes the TL sensitivity distribution of Antarctic equilibrated ordinary chondrites.

Natural Thermoluminescence–For hot desert meteorite finds, natural TL levels generally follow theoretical decay curves (Benoit *et al.*, 1993b). For Antarctic meteorites, however, the connection between natural TL levels and terrestrial ages is poor (Benoit, 1995). Meteorites exposed on the ice surface in Antarctica experience higher temperatures than meteorites buried in the ice so that meteorites on the surface experience higher rates of TL decay. Thus the natural TL levels of Antarctic meteorites reflect surface exposure duration rather than terrestrial age.

Heterogeneity of natural TL levels within several equilibrated ordinary chondrites is modest (Fig. 7) because natural TL shows only minimal dependence on depth (Benoit and Chen, 1996). Paired

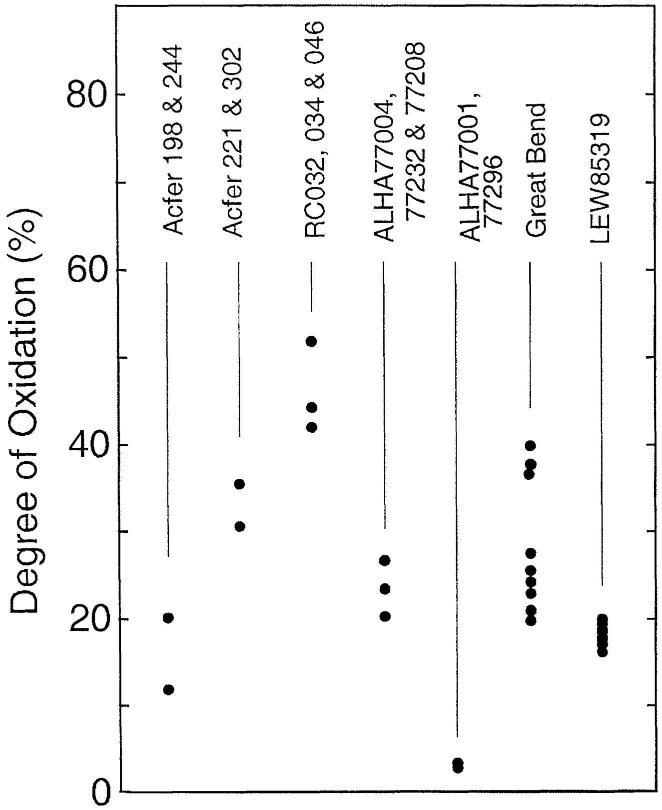

FIG. 4. Degree of oxidation, determined from Mössbauer spectroscopy, for paired fragments and multiple samples from meteorite finds. Heterogeneity in degree of oxidation is limited within meteorites, but significant differences are noted between meteorites.

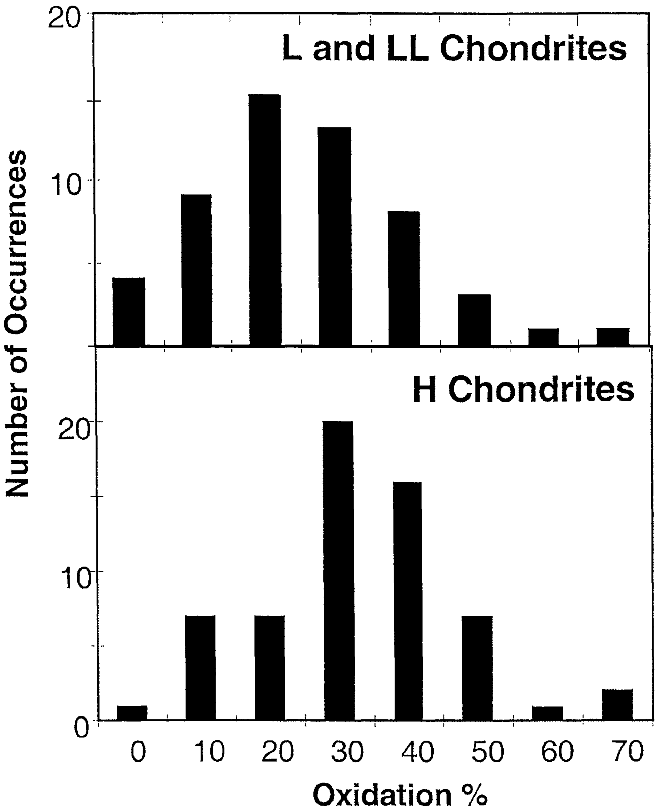

Fig. 5. Degree of oxidation for 115 ordinary chondrite finds from hot deserts based on Mössbauer spectroscopy. Data from Bland *et al.* (1998).

fragments should have the same natural TL levels, allowing for sample heterogeneity of <15%, variations up to 50% being observed in samples with natural levels <1 krad. Table 13 summarizes the natural TL distribution of Antarctic equilibrated ordinary chondrites. The natural TL levels of achondrites have been heavily affected by nonthermal drainage and are more homogeneous than the natural TL levels of ordinary chondrites (Sears *et al.*, 1991b). Any suggestion of pairing for these meteorites is thus "suggestive" rather than "definitive." The database for carbonaceous, lunar, enstatite, and non-Antarctic finds is too small for generalization.

THE MECHANICS OF PAIRING AND DEGREES OF UNCERTAINTY

A pairing analysis consists of first suggesting a linkage between two or more fragments and then supporting the proposed pairing with additional descriptive or analytical data. A pairing analysis inevitably begins with basic classification of samples. Table 3 lists the methods for pairing meteorites in the major meteorite classes. Any of the listed methods can be used to suggest a pairing, but primary criteria should be used when possible to support the pairing.

Little or no uncertainty is associated with a refuted pairing. As noted above, we can calculate either relative or true likelihood of pairing using Eq. (1). Matches in various pairing criteria will affect the comparison statistic, P_{rel}:

$$P_{rel} = P_{rel*} \times P_{ss} \times P_{brecc} \times P_{cre} \times P_{solar} \times P_{3He} \times P_{tage} \times P_{weath} \times P_{NatTL} \qquad (5)$$

where P_{rel*} is class or type abundance (Table 1); P_{ss} is shock stage abundance (Table 5); P_{brecc} is breccia abundance (Table 6); P_{cre}, P_{solar}, and P_{3He} are abundance of cosmic-ray exposure age, abundance of solar-gas-bearing meteorites, and abundance of light noble gas depleted meteorites, respectively (Table 7); P_{tage} is abundance of meteorites of similar terrestrial age (Table 8); P_{weath} is weathering class, Mössbauer, or TL sensitivity match abundance (Table 9, 10, 11, or 12); and P_{NatTL} is the abundance of meteorites with similar natural TL levels (Table 13).

It is highly unlikely that data will be available for all criteria or that all criteria will be applicable. In these cases, the factors are given a value of 1.0. It is possible to produce a P_{rel} of 0, if one set of the pairing data is unusual relative to most meteorites, resulting in a factor value of 0 (*e.g.*, an unusual shock classification in Table 5).

TABLE 11. Distribution of degree of oxidation exhibited by meteorite finds from hot deserts.*

Oxidation (%)	L(LL) (%, $n = 54$)	H (%, $n = 61$)
0–9	0.07	0.02
10–19	0.17	0.11
20–29	0.28	0.11
30–39	0.24	0.33
40–49	0.15	0.26
50–59	0.06	0.11
60–69	0.02	0.02
70+	0.02	0.03

*From Mössbauer spectroscopy.
Data from Bland *et al.* (1998).

TABLE 12. Distribution of TL sensitivity of Antarctic equilibrated ordinary chondrites.

TL sensitivity Dhajala = 1.0	H (%, $n = 183$)	L (%, $n = 266$)	LL (%, $n = 143$)
<0.1	1.6	4.9	4.2
0.1–0.16	2.2	1.9	2.1
0.16–0.25	6.6	5.3	2.8
0.25–0.4	14.8	8.3	7.7
0.4–0.63	31.7	15.8	5.6
0.63–1.0	16.4	13.2	9.8
1.0–1.6	9.3	18.4	11.9
1.6–2.5	7.7	13.2	11.9
2.5–4.0	4.9	10.9	14.0
4.0–6.3	4.9	5.6	19.6
6.3–10.0	0.0	1.9	7.7
10.0–15.0	0.0	0.8	2.8
15.0–25.0	0.0	0.0	0.0

Data from Benoit *et al.* (1992, 1993a, 1994) and unpublished data. Adjusted for possible pairings.

TABLE 13. Distribution of natural TL levels of Antarctic equilibrated ordinary chondrites.*

Natural TL (krad)	Abundance (%)
<0.1	0.6
0.1–0.16	0.1
0.16–0.25	0.7
0.25–0.4	0.6
0.4–0.63	1.9
0.63–1.0	2.3
1.0–1.6	2.7
1.6–2.5	3.4
2.5–4.0	2.0
4.0–6.3	4.0
6.3–10.0	7.4
10.0–16.0	10.0
16.0–25.0	11.8
25.0–40.0	14.9
40.0–63.0	17.3
63.0–100	12.6
100–160	5.5
160–250	1.9
>250	0.3

*At 250 °C in the glow curve.
Data from Benoit *et al.* (1992, 1993a, 1994, and unpublished data).

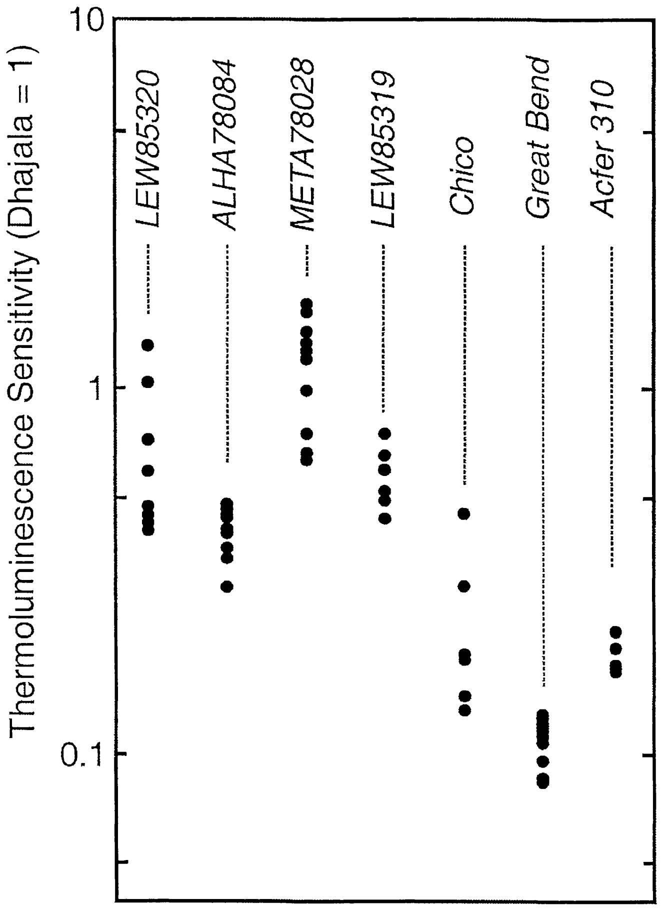

FIG. 6. Range of TL sensitivity in equilibrated ordinary chondrite finds. Samples were chips taken at set intervals in profiles through large meteorites.

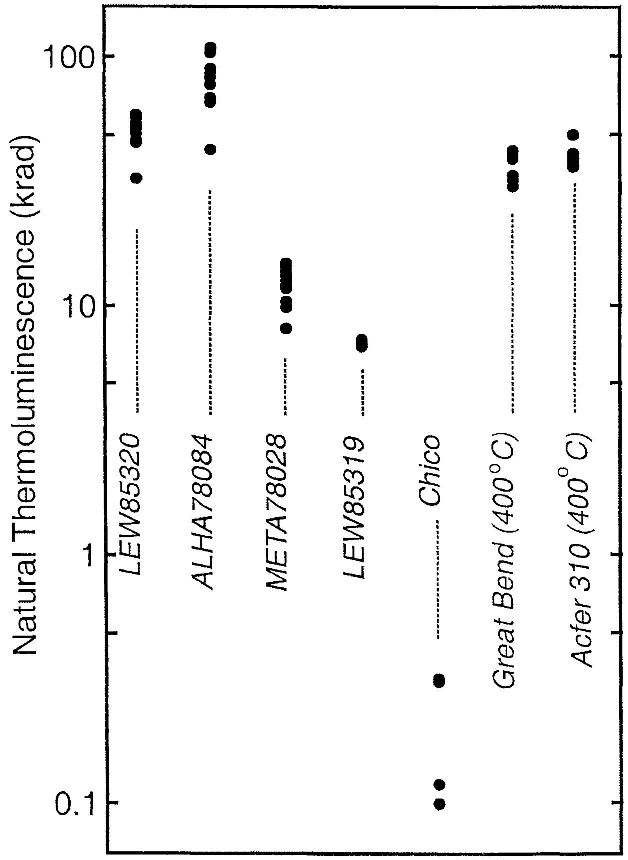

FIG. 7. Range of natural TL levels in equilibrated ordinary chondrite finds. Samples were taken from profiles through large meteorites. Thermoluminescence levels for Great Bend are for the 400 °C portion of the glow curve.

TABLE 14. Descriptors of relative pairing certainty for $n = 9$.

Pairing score (%)	Descriptor
>90	Likely
80–90	Probable
70–80	Possible
50–70	Potential
<50	Candidate or Unlikely

This results in an apparent 100% likelihood of pairing from Eq. (4). This anomaly reflects the scarcity of data in the extremes of distributions; and to avoid an excessive claim of certainty, we assign factors with a value of 0 at least a nominal value of 0.01.

A COMPILATION OF PROPOSED PAIRINGS

A compilation of suggested pairings in the literature appears in the appendix. Although we have used primary sources in our assessment, we reference compilations where available, especially for the large Antarctic meteorite collection. Approximately 2275 samples are listed (although the first sample of each pairing group is not given a separate entry). For each proposed pairing, we indicate the type of data used and give an assessment using our probability approach. We have chosen to assess relative pairing likelihood, using $n = 9$. The true likelihood of pairing may be significantly less, especially for some Antarctic sites where n may exceed hundreds of meteorites, but the relative likelihood stresses the abundance and importance of the supporting data for individual pairing groups. Approximately 390 pairing groups are evaluated, ranging in size from 2 to ~100 members.

We include a number of refuted, or challenged, pairings. These cases are not typically included in compilations (Scott, 1984a, being an exception) but are worthy of note when favored pairings were refuted by additional data. A few meteorites have multiple entries, reflecting their proposed inclusion in several independent pairing groups.

THREE EXAMPLES

Discussions of the trials and tribulations of pairing studies are given by Scott (1984a), Takeda (1991), and Schultz *et al.* (1991). The following cases are intended to illustrate the value of the present approach.

Acfer 097 and Acfer 209 were paired with Acfer 059 by Bischoff *et al.* (1993). The meteorites were classified as CR chondrites and were found in the same region of the Sahara Desert. Eight other samples were also placed in this pairing group (Appendix). The samples are petrologically similar and have similar olivine and metal compositions. Bulk composition (from neutron activation analysis), C and N stable isotope relative abundance, cosmogenic noble gas abundances, and ^{26}Al activity are also cited as being similar for these samples. Despite the large amount of data presented for pairing Acfer 097 and Acfer 209, most of the data cannot be used to quantitatively determine pairing certainty. There are only two CR falls (Al Rais, Renazzo) and about five Antarctic specimens, and thus it is not possible to establish the degree of variation of most characteristics in the group. The pairing argument thus resolves into two criteria, proximity and rarity. The samples were found within 10 km of each other, thus well within the range considered supportive of pairing. From Table 1 we find that the abundance of CR chondrites among modern falls is 0.3%. There are no other applicable modifiers (Eq. (3)), so P_{rel} is set to 0.003. Substituting this into Eq. (4), using $n = 9$, we find a relative certainty factor (P_{pair}) of 0.973. Using the qualitative descriptors from Table 14, we would refer to this pairing as "likely." The analytical data are considered supportive of pairing but do not increase the degree of certainty.

The Antarctic meteorite Elephant Moraine (EET) 90132 was paired with the large EET 90053 group by Mason and Clarke (1992) and listed as paired in the compilation of Grossman (1994). Both are classified as L6 and were assigned weathering classes of B and A/B, respectively. No other relevant data are available. There is nothing in the present data to refute a possible pairing. The meteorites are texturally similar and are within a weathering class of each other. To assess the certainty associated with EET 90132 being a member of this pairing group, we first use rarity (Table 1), setting $P_{rel'}$ to 0.26. These meteorites are not described as breccias and thus do not qualify for the brecciation modifier (Table 6). The sample receives a weathering class modifier, P_{weat}, of 0.443 (Table 9). Solving Eq. (3), we find a P_{rel} of 0.115. Using this in Eq. (4), with $n = 9$, results in a relative certainty factor of 33.2%, or a label of "proposed," the lowest ranking (Table 14). This is clearly not a strong pairing. The pairing could be strengthened (or tested) by the acquisition of additional data. For example, if the samples were examined petrographically and given shock classifications and were found to both be S3, the most common classification for L6 chondrites, an additional modifier of P_{ss} with a value of 0.44 would be added. This would result in a relative certainty factor of 80.1% and would be described as "probable" (Table 14). If both meteorites were found to have shock classifications of S5, P_{ss} would have a value of 0.12, and the relative certainty factor would be 94.2%, and the pairing would be described as "likely."

The Antarctic meteorites MacAlpine Hills (MAC) 88132 and MAC 88133 were classified as H6 and suggested as paired by Mason *et al.* (1990) with MAC 88130 on the basis of petrographic features. Thermoluminescence data were obtained for these meteorites (Benoit *et al.*, 1990) and the pairing with MAC 88130 was refuted on the basis of natural TL. MacAlpine Hills 88132 and MAC 88133 have natural TL levels of 61.8 and 58 krad, respectively, whereas MAC 88130 has a natural TL level of only 47 krad. MacAlpine Hills 88132 and MAC 88133 were both assigned to weathering class B/C and have TL sensitivities of 0.91 and 0.85 relative to Dhajala. Evaluating this proposed pairing differs from the previous examples in the abundance of data, and in the need for data selectivity. The abundance of H6 chondrites is 9.6% in modern falls, and thus we set $P_{rel'}$ to 0.096 (Table 1). The natural TL data are closest to a log value of 1.8, giving a P_{NatTL} of 0.173. Assigning a score to the weathering criterion, P_{weath}, requires a choice of which data to use. We can use the visual descriptive classification (Table 9), giving a factor of 0.404 or we can use the induced TL data (Table 12), giving a factor of 0.164. In the present case, we chose to use the induced TL data. Multiplying these factors together, we obtain a $P_{rel'}$ of 0.0027. Solving Eq. (4) with $n = 9$, the relative pairing score is 97.6%. We would describe this pairing as "likely" (Table 14).

CONCLUSIONS

We have described the currently available methods for identifying meteorite fragments that are part of the same fall. Pairings can be evaluated quantitatively, taking into consideration 11 properties of meteorites. This approach provides an indication of certainty and identifies other types of data that might be obtained.

Pairing analysis is truly "non-trivial." The apparently simple task of considering the pairing of a few meteorites can, and should, involve consideration of petrography, rarity, and possibly space and terrestrial history indicators. As such, pairing involves consideration of uncertainty. We suggest that even where pairing analyses are a minor element of a larger study, the issue of uncertainty must be discussed and the data used to reduce uncertainty should be discussed.

A second issue is whether or not pairing analyses are always needed or relevant. As noted by Schultz *et al.* (1991), a detailed pairing analysis involves considerable effort but may have minimal influence on the final result of the study. This, however, cannot always be assumed. For this reason, we suggest that primary data should be reexamined for pairings of interest and an assessment made of pairing certainty. Simple lists of possible pairings without documentation of the data used for pairing should be regarded with skepticism.

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APPENDIX

TABLE 1A. Listing of literature pairings. Pairing groups are named by the lowest numbered member, or by alphabetical order.

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
Acfer		**Acfer**			
26	H5/6	2	a,b,d	98.2	C
33	L6	19	a,b,d	97.1	C
34	L6	19	a,b,d	97.1	C
41	L/LL6	19	a,b,d	97.1	C
42	H5	25	a,b,d	66.6	C
44	L6	40	a,b,d	92.2	C
48	H4–6	16	a,b,d	98.8	C
71	L6	68	a,b,d	73.1	C
72	L5/6	40	a,b,d	99.7	C
76	H5	31	a,b,d	71.4	C
77	L6	9	a,b,d	96.2	C
87	CR3	59	a,b,d	97.3	C
89	H5	14	a,b,d	91.2	C
93	L5	17	a,b,d	98.5	C
95	H3.7	28	a,b,d	99.7	C
97	CR3	59	a,b,d	97.3	C
98	H5	46	a,b,d	98.4	C
99	H5	27	a,b,d	89.4	C
102	L3–5	39	a,b,d	99.5	C
103	H5	20	a,b,d	93.7	C
113	LL6	106	a,b,d	99.9	C
114	CR2	59	a,b,d	97.3	C
118	L6	105	a,b,d	99.2	C
120	LL6	30	a,b,d	83.9	C
121	L5–6	7	a,b,d	99.7	C
124	LL5–6	91	a,b,d,e,f	99.9	C
126	LL5–6	56	a,b,d	99.8	C
127	L6	125	a,b,d	93.5	C
130	H5	27	a,b,d	93.7	C
135	H5	127	a,b,d	91.2	C
139	CR2	128	a,b,d	97.3	C
141	H5	130	a,b,d	97.0	C
143	L6	101	a,b,d	64.8	C
144	L6	125	a,b,d	93.5	C
145	L6	69	a,b,d	91.2	C
148	H5	136	a,b,d	77.9	C
150	H5	137	a,b,d	77.9	C
151	H5	25	a,b,d	91.2	C
153	H3.8	28	a,d,g	99.7	D
155	L6	125	a,b,d	91.2	C
156	L6	125	a,b,d	91.2	C
157	L6	69	a,b,d	91.2	C
158	H4/5	117	a,b,d	97.0	C
164	H5	152	a,b,d	71.4	C
165	H5–6	154	a,b,d	82.2	C
166	H3–5	162	a,d,g	98.4	D
167	L5	140	a,b,d	98.5	C
171	H3.7	28	a,b,d,g	98.1	C,D
174	LL6	106	a,b,d	99.8	C
175	LL5–6	160	a,b,d,e,f	99.1	AE
176	LL5–6	175	a,b,d	99.9	C
178	H3.7	178	a,b,d	98.1	C
180	H3.9–5	162	a,b,d,g	97.8	C,D
Acfer		**Acfer**			
181	L6	83	a,b,d	70.0	C
182	CH	182	a,b,d	99.1	C
183	H5	25	a,b,d	91.2	C
184	H5	55	a,b,d	97.0	C
185	LL5	57	a,b,d	95.5	C
186	CR2	59	a,b,d	97.3	C
187	CR2	59	a,b,d	97.3	C
190	L6	125	a,b,d	93.5	C
191	L6	125	a,b,d	93.5	C
195	H6	132	a,b,d	88.8	C
198	H6	132	a,b,d	88.8	C
204	H3	129	a,b,d	98.1	C
205	H5	3	a,b,d	71.4	C
206	H5	161	a,b,d	89.5	C
207	CH	182	a,b,d	99.1	C
208	LL5	175	a,b,d	98.4	C
209	CR2	97	a,b,d	97.3	AF
209	CR2	59	a,b,d	97.3	C
210	H3.7	178	a,b,d,g	99.7	C,D
211	H3.9	22	a,d,g	98.1	D
212	H5	136	a,b,d	97.3	C
213	L6	125	a,b,d	93.5	C
214	CH	182	a,b,d	99.1	C
220	H5	84	a,b,d	82.2	C
221	H5	27	a,b,d	89.5	C
223	L/LL6	179	a,b,d	87.0	C
224	H5/6	27	a,b,d	82.2	C
226	H5	194	a,b,d	71.4	C
228	L5	64	a,b,d	99.3	C
229	H5	196	a,b,d	98.4	C
230	H5	27	a,b,d	93.7	C
231	H4/5	65	a,b,d	94.0	C
235	H5	27	a,b,d	93.7	C
237	H3	28	a,b,d	99.7	C
242	L6	241	a,b,d	88.6	C
244	H6	132	a,b,d	88.1	C
245	H5	25	a,b,d	71.4	C
246	L6	125	a,b,d	93.5	C
249	H5/6	27	a,b,d	93.7	C
250	H6	250	a,b,d	97.4	C
251	LL5–6	126	a,b,d	96.1	C
251	LL5–6	160	a,b,d,e,f	99.1	AE
252	L6	40	a,b,d	92.6	C
253	LL5–6	175	a,b,d	96.1	C
254	L6	40	a,b,d	92.6	C
255	L6	15	a,b,d	99.2	C
263	L6	125	a,b,d	93.5	C
266	L6	83	a,b,d	70.0	C
268	LL4–6	193	a,b,d	96.1	C
268	LL4–6	160	a,b,d,e,f	99.1	AE
269	LL6	236	a,b,d	83.9	C
270	CR2	59	a,b,d	97.3	C
271	H6	258	a,b,d	96.1	C
Acfer		**Acfer**			
276	H5	85	a,b,d	89.5	C
278	H5	84	a,b,d	93.7	C
279	H5	25	a,b,d	91.2	C
280	L6	40	a,b,d	93.8	C
283	H5	11	a,b,d	71.4	C
285	H4/5	70	a,b,d	71.4	C
286	H6	250	a,b,d	81.2	C
289	CR2	59	a,b,d	97.3	C
290	L6	168	a,b,d	77.3	C
291	H6	250	a,b,d	88.8	C
295	LL6	236	a,b,d	94.0	C
298	L6	168	a,b,d	88.6	C
300	H6	282	a,b,d	97.4	C
301	H4	65	a,b,d	97.8	C
302	H5	27	a,b,d	93.7	C
303	H5/6	256	a,b,d	82.4	C
305	L6	168	a,b,d	88.6	C
306	L6	116	a,b,d	70.0	C
310	H6	257	a,b,d	88.8	C
311	CR2	59	a,b,d	97.3	C
312	L5	215	a,b,d	98.3	C
313	H5	27	a,b,d	93.7	C
314	H6	173	a,b,d	98.0	C
316	H6	250	a,b,d	88.8	C
319	L6	309	a,b,d	84.6	C
320	H5	38	a,b,d	82.2	C
Aguemour		**Aguemour**			
4	H5	1	a,b,d	91.2	C
Aguemour		**Acfer**			
6	L3.8	133	a,b,d	94.7	C
Aguemour		**Aguemour**			
15	L5	14	a,b,d	94.1	C
16	L5	14	a,b,d	88.5	C
ALHA		**ALHA**			
77005	Sher.	77005	a,c,d,e,h	ref.	E
77009	H4	77009	a,d,f,h	ref.	P
77015	L3.5	77011	a,d,f,h	97.3	P
77025	H5	77021	a,d,f,g	76.1	P
77031	L3	77011	a,d,f	97.7	P
77033	L3	77011	a,d,f	97.3	P
77034	L3	77011	a,d,f	97.7	P
77036	L3	77011	a,d,f	97.1	P
77043	L3	77011	a,d,f	97.7	P
77047	L3	77011	a,d,f,h	98.4	P
77049	L3	77011	a,d,f	97.7	P
77050	L3.6	77011	a,d,f,h	98.4	P
77052	L3	77011	a,d,f,h	98.4	P
77061	H5	77021	a,d,f	74.2	P
77062	H5	77021	a,d,f,h	85.1	P
77064	H5	77021	a,d,f	74.2	P
77071	H5	77021	a,d,f,h	85.1	P
77074	H5	77021	a,d,f	74.2	P
77081	Acap	77081	a,d,f	99.9	P
ALHA		**ALHA**			
77086	H5	77021	a,d,f,h	76.1	P
77088	H5	77021	a,d,f,h	76.1	P
77115	L3	77011	a,d,f,h	97.7	P
77119	H5	77118	a,d,f	60.2	P
77124	H5	77118	a,d,f,h	ref.	P
77140	L3	77011	a,d,f,h	98.4	P
77148	H6	77144	a,d,f	73.7	P
77160	L3	77011	a,d,f,h	99.8	P
77163	L3	77011	a,d,f,h	98.6	P
77164	L3	77011	a,d,f,h	99.8	P
77165	L3	77011	a,d,f,h	ref.	P
77166	L3	77011	a,d,f,h	99.8	P
77167	L3.4	77011	a,d,f,h	99.8	P
77170	L3	77011	a,d,f	97.7	P
77175	L3	77011	a,d,f,h	ref.	P
77177	H5	77012	d,e	99.0	V
77178	L3	77011	a,d,f	97.7	P
77185	L3	77011	a,d,f,h	99.8	P
77190	H4	77004	a,d,f,h	93.2	P
77191	H4	77004	a,d,f,g,h	98.9	P
77192	H4	77004	a,d,f,h	93.2	P
77208	H4	77004	a,d,f,g,h	98.9	P
77211	L3	77011	a,d,f,h	97.7	P
77214	L3.4	77167	a,d,f,h	ref.	P
77215	L3	77216	a,d,f,h	98.3	P
77216	L3.7/3.9	77216	a,d,f,h	99.5	P
77217	L3	77216	a,d,f,h	98.3	P
77219	Mes.	77219	a,c,d	93.0	I
77221	H4	77004	d,f,h	93.2	P
77223	H4	77004	a,d,f,h	93.2	P
77224	H4	77004	a,d,f,h	93.2	P
77225	H4	77004	a,d,f,h	93.2	P
77226	H4	77004	a,d,f,h	93.2	P
77232	H4	77004	a,d,f,g,h	93.2	P
77233	H4	77004	a,d,f,h	93.2	P
77241	L3	77011	a,d,f,h	97.3	P
77244	L3	77011	a,d,f,h	97.7	P
77249	L3.4	77167	a,d,f,h	93.2	P
77250	IA	76002	a,c,d	93.9	P
77252	L3	77216	a,d,f,h	97.1	P
77257	Ure	77257	d,e	ref.	H
77260	L3.5	77011	a,d,f,h	93.2	P
77263	IA	76002	a,c,d	93.9	P
77264	H5	77014	a,d,f	94.1	P
77272	L6	77272	a,d,f,h	ref.	P
77273	L6	77272	a,d,f,h	98.4	P
77280	L6	77272	a,d,f,h	98.4	P
77282	L6	77272	a,d,f,h	98.4	P
77288	H6	77271	a,d,f,h	95.2	P
77289	IA	76002	a,c,d	93.9	P
77290	IA	76002	a,c,d	93.9	P
77292	L6	77001	a,d,f	34.1	P
77295	EH3	77156	a,c,d	97.0	P

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.
ALHA		**ALHA**				**ALHA**		**ALHA**				**ALHA**		**ALHA**				**ALHA**		**ALHA**			
77296	L6	77001	a,d,f,g,h	80.0	P	79026	H5	78075	d,e,f	93.6	V	81044	H4	81041	a,d,f,h	93.2	P	82135	CK4	82135	a,d	91.4	
77297	L6	77001	a,d,f,g,h	ref.	P	79032	H5	79031	a,d,f	60.2	P	81045	H4	81041	a,d,f,h	93.2	P	83007	LL3.2/3.4	79003	a,d,f	97.9	
77297	L6	77296	d,f,g	99.7	Y	79045	L3	77011	a,d,f,h	98.4	P	81046	H4	81041	a,d,f	88.7	P	83008	L3.4/3 7	78046	a,d,f,h	99.6	
77302	Euc	76005	a,c,d,g,h	87.3	P	79054	H5	77274	d,e,f,g,h	98.2	V	81047	H4	81041	a,d,f,h	93.5	P	83015	Aub	83009	a,c,d	91.3	P
77303	L3	77011	a,d,h	98.6	P	80102	Euc	78132	a,c,d,e	63.3	H	81048	H4	81041	a,d,f,h	93.5	P	83016	CM2	81002	a,d	87.3	P
78013	L3	77011	a,d	91.3	P	80103	L6	80101	a,d,f,h	63.3	P	81049	H4	81041	a,d,f	89.1	P	83018	EL6	81021	a,d	93.0	G
78015	L3	77011	a,d,h	91.3	P	80105	L6	80101	a,d,f,h	63.3	P	81050	H4	81041	a,d,f,h	93.2	P	83026	CO3	77003	a,d	94.7	
78017	L3	77011	a,d,f	97.1	P	80107	L6	80101	a,d,f,h	63.3	P	81051	H4	81041	a,d,f,h	93.5	P	83038	L3.8	77011	a,d,f	97.3	
78019	Ure	78019	a,c,d	94.7	P	80108	L6	80101	a,d,f,h	63.3	P	81052	H4	81041	a,d,f,h	93.2	P	83070	LL6	78153	a,d,f	89.3	
78037	L3	77011	a,d,f	97.1	P	80110	L6	80101	a,d,f,h	63.3	P	81053	L3	77011	a,d,f	97.3	P	83102	CM2	83100	a,d,h	95.6	P
78038	L3.4	77167	a,d,f,h	99.3		80112	L6	80101	a,d,f,h	63.3	P	81059	Mes.	77219	a,c,d,e	ref.	I	83106	CM2	83100	a,d	87.3	
78040	Euc	76005	a,c,d,h	87.3	P	80113	L6	80101	a,d,f,h	63.3	P	81060	L3	77011	a,d,f,h	98.4	P	83108	CO3	77003	a,d	94.7	
78041	L3.4	77167	a,d,f,h	99.3	P	80114	L6	80101	a,d,f,h	63.3	P	81061	L3	77011	a,d,f,h	ref.	P	84007	Aub	83009	a,c,d,e	91.3	H
78043	L6	77261	d,f,g	92.8	Y	80115	L6	80101	a,d,f,h	63.3	P	81065	L3	77011	a,d,f	97.7	P	84008	Aub	83009	a,c,d,e	ref.	H
78045	L6	78043	a,d,h	99.4	P	80116	L6	80101	a,d,f,h	63.3	P	81066	L3	77011	a,d,f	97.3	P	84010	Aub	83009	a,c,d	91.3	G
78047	H5	77268	d,f,g	99.2		80117	L6	80101	a,d,f,h	63.3	P	81067	H5	78075	a,d,e	73.3	V	84011	Aub	83009	a,c,d,e	91.3	H
78105	L6	78103	a,d,f,g,h	96.9	P	80119	L6	80101	a,d,f	34.1	P	81069	L3	77011	a,d,f	97.7	P	84012	Aub	83009	a,c,d	91.3	G
78108	H5	77259	d,e	89.3	V	80120	L6	80101	a,d,f	34.1	P	81085	L3	77011	a,d,f	97.3	P	84013	Aub	83009	a,c,d	91.3	G
78113	Aub	84007	d,e	ref.	H	80121	H4	80106	a,d,f,h	93.4	P	81087	L3	77011	a,d,f	97.7	P	84014	Aub	83009	a,c,d	91.3	G
78114	L6	77261	d,f,g	96.3	Y	80121	H4	77262	a,d,e,f	97.4	V	81092	H4	80131	d,e,f	99.8	V	84015	Aub	83009	a,c,d	91.3	G
78115	H6	77258	d,f,g	97.0	Y	80124	H5	80111	a,d,f	74.2	P	81098	Mes.	77219	a,c,d,e	ref.	I	84016	Aub	83009	a,c,d	91.3	G
78132	Euc	78132	a,c,d,e,h	99.8	H,AC	80125	L6	80101	a,d,f,h	ref.	P	81098	Mes.	77219	a,c,d	93.0	P	84017	Aub	83009	a,c,d	91.3	G
78134	H4	77262	d,f,g	97.8		80126	H6	80122	a,d,f	97.0	P	81101	Ure	77257	d,e	ref.	H	84018	Aub	83009	a,c,d	91.3	G
78158	Euc	76005	a,c,d	87.3	P	80127	H5	80111	a,d,f	74.2	P	81103	H6	81035	a,d,f,h	ref.	P	84019	Aub	83009	a,c,d	91.3	G
78162	L3.4	77167	a,d,f,h	98.3	P,X	80128	H4	80106	a,d,f,h	98.6	P	81107	L6	80101	a,d,f,h	ref.	P	84020	Aub	83009	a,c,d	91.3	G
78165	Euc	76005	a,c,d,h	97.8	P	80129	H5	80111	a,d,f	74.2	P	81112	H6	81035	a,d,f,h	70.0	P	84021	Aub	83009	a,c,d	91.3	G
78170	L3	77011	a,d,f,h	98.3	P	80130	H6	80122	a,d,f	70.0	P	81121	L3	77011	a,d,f	97.1	P	84022	Aub	83009	a,c,d	91.3	G
78176	L3.4	77011	a,d,f	97.1	P	80131	H4	80106	a,d,e,f	ref.	P,V	81123	LL6	78153	a,d,f	89.3		84023	Aub	83009	a,c,d	91.3	G
78180	L3.4	77167	a,d,f	97.1	P,X	80132	H5	80111	a,d,f	74.2	P	81145	L3	77011	a,d,f	97.1	P	84024	Aub	83009	a,c,d	91.3	G
78186	L3	77011	a,d	91.4	P	80133	L3	77011	a,d,f	97.1	P	81156	L3	77011	a,d,f	97.7	P	84029	CM2	83100	a,d,h	87.3	P
78188	L3	77011	a,d,f	97.3	P	81001	Euc	78132	a,d,e	ref.	H	81162	L3	77011	a,d,f	97.7	P	84030	CM2	83100	a,d	87.3	P
78196	H4	78193	a,d,f	89.1	P	81002	CM2	81002	a,d	87.3	P	81187	Acap	81187	a,d	99.9	P	84031	CM2	83100	a,d	87.3	P
78213	H6	78211	a,d,f	83.8	P	81003	CV3–an	81003	a,c,d	96.8	P	81190	L3	77011	a,d,f	97.7	P	84032	CM2	83100	a,d	87.3	P
78215	H6	78211	a,d,f	70.0	P	81004	CM2	81002	a,d	87.3	P	81191	L3	77011	a,d,f	97.7	P	84033	CM2	81002	a,d,h	87.3	G
78221	H5	78209	a,d,f	74.2	P	81006	Euc	76005	a,c,d	87.3	P	81214	L3	77011	a,d,f	97.7	P	84034	CM2	83100	a,d	87.3	P
78223	H4	78193	a,d,f	80.0	P	81007	Euc	76005	a,c,d	87.3	P	81229	L3.4	77167	a,d,f	97.7	P	84035	CM2	83100	a,d	87.3	G
78225	H5	78209	a,d,f	74.2	P	81008	Euc	78132	a,c,d,e	76.0	H	81243	L3	77011	a,d,f	97.7	P	84036	CM2	81002	a,d	87.3	G
78227	H5	78209	a,d,f	59.8	P	81009	Euc	78132	a,c,d,e	76.0	H	81251	LL3.2/3.4	76004	a,d,f,h	99.0	P	84037	CV3	84028	a,d	93.9	
78229	H6	78211	a,d,f	83.8	P	81010	Euc	78132	a,c,d,e	76.0	H	81258	CV3–an	81003	c,d	97.7	P	84038	CK4	82135	a,d	91.4	
78231	H6	78211	a,d,f	70.0	P	81012	Euc	76005	a,c,d	87.3	P	81259	L3.4	77167	a,d,f	98.7	P	84039	CM2	81002	a,c,d	87.3	G
78233	H5	78209	a,d,f	59.8	P	81021	EL6	81021	a,c,d,f,h	93.0	P	81260	EL6	81021	a,c,d,h	93.0	P	84040	CM2	83100	a,d	87.3	G
78235	L3.4	77167	a,d,f,h	98.3	P,X	81022	H4	77009	a,d,f,h	ref.	P	81261	Acap	77081	a,d	99.9	P	84041	CM2	83100	a,d	87.3	G
78236	L3	77011	a,d	91.3	P	81023	L5	81018	a,d,f	77.4	P	81262	L6	80101	a,d,f	59.9	P	84042	CM2	83100	a,c,d	87.3	P
78238	L3	77011	a,d	91.3	P	81025	L3.6	77011	a,d,f,h	98.5	P	81272	L3	77011	a,d,f	97.7	P	84043	CM2	83100	a,d	87.3	G
78239	L3.4	77167	a,d,f	97.1	P,X	81028	L6	81027	a,d,f,h	63.3	P	81280	L3	77011	a,d,f	97.7	P	84044	CM2	83100	a,c,d,h	87.3	P
78243	L3	77011	a,d	91.3	P	81029	L6	81027	a,d,f,h	90.8	P	81292	L3	77011	a,d,f	97.7	P	84045	CM2	83100	a,d	87.3	G
78251	L6	78103	a,d,f,g,h	83.8	P	81030	L3.4	77011	a,d,f	97.1	P	81299	L3	77011	a,d,f	97.7	P	84046	CM2	81002	a,c,d	87.3	G
78261	CM2	81002	a,d	87.3	P	81031	L3.4	77011	a,d,f	97.1	P	81315	Acap	77081	a,d	99.9	P	84047	CM2	83100	a,d	87.3	G
78262	Ure	78019	a,c,d	94.7	P	81032	L3.4	77011	a,d,f,h	95.6	P	82100	CM2	81002	a,d	87.3	P	84048	CM2	83100	a,d	87.3	G
79001	L3	77011	a,d,f,h	98.4	P	81038	H6	81035	a,d,f,h	85.2	P	82102	H5	79029	d,e,f	94.6	V	84049	CM2	83100	a,d	87.3	G
79017	Euc	78132	a,c,d,e,h	99.8	H	81039	H5	78075	a,d,e,f	98.6	V	82130	Ure	82106	a,c,d,h	94.7	P	84050	CM2	81002	a,d	87.3	G
79022	L3.7/4	77215	a,d,f	99.5	W	81043	H4	81041	a,d,f,h	93.5	P	82131	CM2	81002	d	87.3	P	84051	CM2	83100	a,d	87.3	G

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
ALHA		**ALHA**			
84053	CM2	81002	a,d	87.3	
84054	CM2	81002	a,d	87.3	
84136	Ure	82106	a,d	94.7	
84190	Acap	81187	a,d	99.9	
84191	CM2	81002	a,d	87.3	
84200	EH3	81189	a,c,d	96.0	G
84206	EH3	81189	a,c,d	96.0	G
84220	EH3	81189	a,c,d	96.0	G
84235	EH3	81189	a,c,d	96.0	G
84250	EH3	81189	a,c,d	96.0	G
84254	EH3	81189	a,c,d	96.0	G
85002	CK2	82135	a,d	91.4	
85003	CO3	82101	a,d	94.7	
85004	CM2	83100	a,d	87.3	
85007	C2	85005	a,d	87.3	
85009	C2	85005	a,d	87.3	
85008	C2	85005	a,d	87.3	
85010	C2	85005	a,d	87.3	
85011	C2	85005	a,d	87.3	
85012	C2	85005	a,d	87.3	
85013	C2	85005	a,d	87.3	
85017	L6	85014	d,f,g	99.1	Y
85030	H6	85018	d,f,g	99.5	Y
85031	H6	85030	a,d,f,h	ref.	
85032	H6	85030	a,d,f,h	ref.	
85044	H6	85041	d,f,g	96.8	Y
85045	L3	85026	d,f,g	99.9	Y
85056	H5	85021	d,f,g	99.3	Y
85073	LL6	85066	d,f,g	98.0	Y
85079	LL6	85066	d,f,g	98.9	Y
85080	L6	85027	d,f,g	92.8	Y
85083	L6	85027	d,f,g	95.7	Y
85097	H5	85043	d,f,g	98.4	Y
85102	H5	85021	d,f,g	98.5	Y
85103	L6	85027	d,f,g	97.7	Y
85104	H5	85021	d,f,g	99.5	Y
85105	L6	85027	d,f,g	94.8	Y
85114	H5	85077	d,f,g	96.9	Y
85124	L6	85115	d,f,g	98.5	Y
85141	H5	85091	d,f,g	95.1	Y
85142	H5	85091	d,f,g	99.7	Y
85143	H5	85098	d,f,g	98.3	Y
85145	H5	85021	a,d,f,g	99.9	
85146	H5	85100	d,f,g	98.2	Y
85155	L3.7	77011	a,d,f	99.2	
85159	EH3	81189	a,d	94.1	
ALH		**ALHA**			
86601	H5	78128	d,f,g	85.1	
86602	L6	77261	d,f,g	97.8	Y
ALH		**ALH**			
88006	L4	88002	d,f,g	99.7	Y
88024	H6	88023	d,f,g	97.8	Y
88025	H5	88007	d,f,g	97.7	Y
ALH		**ALHA**			
88028	H5	77268	d,f,g	99.2	
ALH		**ALH**			
88030	H5	88026	d,f,g	97.7	Y
88033	H5	88026	d,f,g	98.8	Y
88035	H5	88026	d,f,g	97.6	Y
88038	H5	88007	d,f,g	95.0	Y
88040	H5	88014	d,f,g	93.8	Y
88042	H5	88029	d,f,g	99.6	Y
88047	H6	88018	d,f,g	99.0	Y
BTNA		**BTNA**			
78002	L6	78001	a,d,f	34.1	P
Dar al Gani		**Dar al Gani**			
062	LL5–6	061	a,b,d,e,f	97.1	AE
171	CO3	005	a,b,d	95.8	AI
173	CO3	005	a,b,d	95.8	AI
186	CO3	005	a,b,d	95.8	AI
188	CO3	005	a,b,d	95.8	AI
189	CO3	005	a,b,d	95.8	AI
191	CO3	005	a,b,d	95.8	AI
192	CO3	005	a,b,d	95.8	AI
194	CO3	005	a,b,d	95.8	AI
203	CO3	005	a,b,d	95.8	AI
204	CO3	005	a,b,d	95.8	AI
231	CO3	005	a,b,d	95.8	AI
303	CO3	005	a,b,c,d	95.8	AI
331	CO3	005	a,b,c,d	95.8	AI
332	CO3	005	a,b,c,d	95.8	AI
400	Lunar	262	d,e	ref.	AI
DRPA		**DRPA**			
78002	IIB	78001	a,c,d	99.9	P
78003	IIB	78001	a,c,d	99.9	P
78004	IIB	78001	a,c,d	99.9	P
78005	IIB	78001	a,c,d	99.9	P
78006	IIB	78001	a,c,d	99.9	P
78007	IIB	78001	a,c,d	99.9	P
78008	IIB	78001	a,c,d	99.9	P
78009	IIB	78001	a,c,d	99.9	P
EET		**EET**			
87501	Meso	87500	a,c,d,g	93.0	AA
87505	IAB	87504	a,d	93.9	
87506	IAB	87504	a,d	93.9	
87508	CK5	87507	a,d	91.4	
87509	How	87503	a,c,d,g	85.7	AA
87510	How	87503	a,c,d,g	85.7	AA
87511	Ure	87511	a,c,d,g	94.7	AA
87512	How	87503	a,c,d,g	ref.	
87513	How	87513	a,d,g	85.7	AA
87514	CK5	87507	a,d,g	ref.	
87517	Ure	87511	a,d,g	94.7	AA
87518	How	87503	a,c,d,g	94.7	AA
87519	CK5	87507	a,d	91.4	
87523	Ure	87511	a,c,d,g	94.7	AA
87526	CK5	87507	a,c,d,g	91.4	
EET		**EET**			
87527	CK5	87507	a,d	91.4	
87529	CK5	87507	a,c,d,g	91.4	
87531	How	87503	a,c,d,g	94.7	AA
87533	L6	87530	d,f,g	93.8	AA
87535	L6	87502	a,d,f,g	99.6	AA
87554	L6	87549	d,f,g	96.2	AA
87556	L6	87541	a,d,f,g	99.8	R,AA
87561	L6	87560	d,f,g	96.8	AA
87564	L4	87557	d,f,g	99.7	AA
87567	L6	87502	a,d,f,g	99.1	AA
87568	L6	87541	a,d,f,g	99.6	R,AA
87571	H5	87571	d,f,g	99.2	AA
87574	L6	87530	d,f,g	93.8	AA
87576	H5	87537	d,f,g	92.8	AA
87583	L6	87536	a,d,f,g	99.1	AA
87584	L6	87530	d,f,g	93.8	AA
87584	L6	87541	a,d,f,g	99.8	AA
87586	L6	87569	a,d,f,g	94.6	AA
87589	L6	87587	a,d,f,g	96.0	AA
87603	L6	87601	a,d,f,g	95.1	AA
87613	L6	87601	a,d,f,g	90.3	AA
87616	L6	87601	a,d,f,g	90.3	AA
87635	L6	87596	a,d,f,g	90.3	AA
87639	L6	87622	a,d,f,g	88.5	AA
87644	L6	87594	a,d,f,g	88.5	AA
87652	L6	87626	a,d,f,g	93.1	AA
87661	L6	87569	a,d,f,g	88.3	AA
87717	Aug	87511	a	94.7	
87747	CR2	87711	a,c,d	97.3	
87759	L6	92055	a,d,f,g	84.0	
87770	CR2	87711	a,c,d	97.3	
87774	L5	87570	a,d,f,g	99.4	AA
87778	H3.9	87726	a,c,d,f	99.6	
87789	L6	87596	a,d,f,g	96.6	AA
87804	L6	87796	a,d,f,g	85.8	AA
87807	L6	87569	a,d,f,g	98.2	AA
87812	CR2	87711	a,c,d	97.3	
87817	L6	87756	a,d,f,g	89.4	AA
87823	H3.9	87726	a,c,d,f	99.6	
87830	L6	87601	a,d,f,g	90.3	AA
87840	H5	87581	a,d,f,g	95.0	AA
87846	CR2	87711	a,c,d	97.3	
87847	CR2	87711	a,c,d	97.3	
87850	CR2	87711	a,c,d	97.3	
87855	L6	87601	a,d,f,g	93.1	AA
87857	L6	87569	a,d,f,g	88.5	AA
87858	L6	87587	a,d,f,g	96.4	AA
90001	CK5	87507	a,c,d,g	91.4	
90002	CK5	87507	a,c,d	91.4	
90003	CK5	87507	a,c,d	91.4	
90004	CK5	87507	a,c,d	91.4	
90005	CK5	87507	a,c,d,g	91.4	
90006	CK5	87507	a,c,d,g	91.4	
EET		**EET**			
90007	CK5	87507	a,c,d,f,g	91.4	
90008	CK5	87507	a,c,d,g	91.4	
90009	CK5	87507	a,c,d,g	91.4	
90010	CK5	87507	a,d	91.4	
90013	CK5	87507	a,c,d,g	91.4	
90014	CK5	87507	a,d	91.4	
90015	CK5	87507	a,c,d,g	91.4	
90016	CK5	87507	a,c,d,g	91.4	
90017	CK5	87507	a,d	91.4	
90018	CK5	87507	a,c,d	91.4	
90022	CK5	87507	a,c,d	91.4	
90023	CK5	87507	a,d	91.4	
90025	CK5	87507	a,c,d,g	91.4	
90026	CK5	87507	a,c,d	91.4	
90027	CK5	87507	a,d	91.4	
90028	CK5	87507	a,d	91.4	
90032	LL6	90031	a,d,f	96.1	
90035	CK5	87507	a,d	91.4	
90036	CK5	87507	a,d	91.4	
90037	L6	90053	a,d,f	34.1	
90038	CK5	87507	a,d	91.4	
90039	CK5	87507	a,d	91.4	
90040	CK5	87507	a,c,d	91.4	
90041	CK5	87507	a,c,d	91.4	
90042	CK5	87507	a,c,d	91.4	
90044	CK5	87507	a,c,d	91.4	
90045	CK5	87507	a,c,d	91.4	
90046	CK5	87507	a,c,d	91.4	
90048	CK5	87507	a,c,d	91.4	
90049	CK5	87507	a,c,d	91.4	
90050	CK5	87507	a,c,d	91.4	
90052	CK5	87507	a,c,d	91.4	
90054	L6	90053	a,d,f,g	ref.	
90055	L6	90053	a,d,f	59.9	
90056	L6	90053	a,d,f	59.9	
90057	L6	90053	a,d,f	59.9	
90058	L6	90053	a,d,f	59.9	
90059	L6	90053	a,d,f	59.9	
90060	L6	90053	a,d,f	34.1	
90061	L6	90053	a,d,f	59.9	
90062	L6	90053	a,d,f	59.9	
90063	L6	90053	a,d,f	59.9	
90064	L6	90053	a,d,f	34.1	
90065	L6	90053	a,d,f	59.9	
90067	L6	90053	a,d,f	59.9	
90068	L6	90053	a,d,f	34.1	
90070	L6	90053	a,d,f	59.9	
90072	L6	90053	a,d,f	34.1	
90073	L6	90053	a,d,f	34.1	
90074	L6	90053	a,d,f	34.1	
90075	L6	90053	a,d,f	34.1	
90077	L6	90053	a,d,f	34.1	
90078	L6	90053	a,d,f	34.1	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.
EET		**EET**				**EET**		**EET**				**EET**		**EET**				**EET**		**EET**			
90079	L6	90053	a,d,f	34.1		90139	L6	90053	a,d,f	34.1		90200	L6	90053	a,d,f	34.1		90266	L6	90204	a,d,f,g	85.8	
90080	L3.4	90080	a,d,f	98.2		90140	L6	90053	a,d,f	34.1		90201	L6	90053	a,d,f	34.1		90267	L6	90053	a,d,f	34.1	
90081	L6	90053	a,d,f	59.9		90141	L6	90053	a,d,f	34.1		90202	L6	90053	a,d,f	59.9		90268	L6	90053	a,d,f	34.1	
90082	L6	90053	a,d,f	59 9		90142	L6	90053	a,d,f	34.1		90203	L6	90053	a,d,f	34.1		90269	L6	90053	a,d,f	58.4	
90084	L6	90053	a,d,f	59.9		90143	L6	90053	a,d,f	59.9		90205	L6	90053	a,d,f	58.4		90270	L6	90053	a,d,f	34.1	
90085	L6	90053	a,d,f	34.1		90144	L6	90053	a,d,f	59.9		90206	L6	90053	a,d,f	34.1		90271	L6	90053	a,d,f	34.1	
90086	L6	90053	a,d,f	59.9		90145	L6	90053	a,d,f	59.9		90208	L6	90053	a,d,f	58.4		90272	L6	90053	a,d,f	34.1	
90087	L6	90053	a,d,f	59.9		90146	L6	90053	a,d,f	59.9		90209	L6	90053	a,d,f	34.1		90274	L6	90053	a,d,f	58.4	
90088	L6	90053	a,d,f	59.9		90147	L6	90053	a,d,f	59.9		90210	L6	90053	a,d,f	59.9		90275	L6	90053	a,d,f	58.4	
90089	L6	90053	a,d,f	59.9		90148	L6	90053	a,d,f	59.9		90211	L6	90053	a,d,f	34.1		90276	L6	90053	a,d,f	34.1	
90090	L6	90053	a,d,f	59.9		90149	L6	90053	a,d,f	59.9		90213	L6	90053	a,d,f	59.9		90277	L6	90053	a,d,f	34.1	
90091	L6	90053	a,d,f	59.9		90150	L6	90053	a,d,f	34.1		90214	L6	90053	a,d,f	34.1		90278	L6	90192	a,d,f	80.2	
90092	L6	90053	a,d,f	34.1		90153	L6	90053	a,d,f	34.1		90216	L6	90053	a,d,f	59.9		90279	L6	90053	a,d,f	34.1	
90093	L6	90053	a,d,f	59.9		90154	L6	90053	a,d,f	58.4		90217	L6	90053	a,d,f	59.9		90280	L6	90053	a,d,f	34.1	
90094	L6	90053	a,d,f	59.9		90155	L6	90053	a,d,f	59.9		90218	L6	90053	a,d,f	59.9		90281	L6	90053	a,d,f	34.1	
90095	L6	90053	a,d,f	59.9		90158	L6	90053	a,d,f,g	ref.		90219	L6	90053	a,d,f	59.9		90282	L6	90053	a,d,f	34.1	
90096	L6	90053	a,d,f	59.9		90159	L6	90071	a,d,f,g	96.6		90220	L6	90053	a,d,f	59.9		90283	L6	90053	a,d,f	34.1	
90101	L6	90053	a,d,f	34.1		90160	L6	90053	a,d,f	59.9		90221	L6	90053	a,d,f	59.9		90284	L6	90053	a,d,f	34.1	
90103	L6	90053	a,d,f	34.1		90161	L6	90053	a,d,f	98.2		90222	L6	90053	a,d,f	59.9		90285	L6	90053	a,d,f	34.1	
90105	L6	90053	a,d,f	34.1		90162	L6	90053	a,d,f	59.9		90223	L6	90053	a,d,f	59.9		90286	L6	90053	a,d,f	34.1	
90107	L6	90053	a,d,f	34.1		90163	L6	90053	a,d,f	59.9		90223	L6	90053	a,d,f	59.9		90287	L6	90053	a,d,f	34.1	
90108	L6	90053	a,d,f	34.1		90164	L6	90053	a,d,f	59.9		90224	L6	90053	a,d,f	59.9		90288	L6	90053	a,d,f	34.1	
90109	L6	90053	a,d,f	34.1		90167	L6	90053	a,d,f	59.9		90225	L6	90053	a,d,f	34.1		90289	L6	90053	a,d,f	34.1	
90110	L6	90053	a,d,f	59.9		90168	L6	90053	a,d,f	59.9		90226	L6	90053	a,d,f	59.9		90290	L6	90053	a,d,f	34.1	
90111	L6	90053	a,d,f	58.4		90169	L6	90053	a,d,f	59.9		90227	L6	90053	a,d,f	59.9		90291	L6	90053	a,d,f	34.1	
90112	L6	90053	a,d,f	58.4		90170	L6	90053	a,d,f	58.4		90228	L6	90053	a,d,f	59.9		90292	L6	90192	a,d,f	80.2	
90113	L6	90053	a,d,f	34.1		90171	L6	90053	a,d,f	34.1		90230	L6	90156	a,d,f,g	97.4		90293	L6	90053	a,d,f	34.1	
90114	L6	90053	a,d,f	34.1		90172	L6	90053	a,d,f	91.1		90231	L6	90192	a,d,f	80.2		90294	L6	90053	a,d,f	58.4	
90115	L6	90076	a,d,f,g	99.0		90173	L6	90053	a,d,f	34.1		90232	L6	90053	a,d,f	58.4		90295	L6	90053	a,d,f	59.9	
90116	L6	90053	a,d,f	34.1		90174	L6	90053	a,d,f	34.1		90234	CK5	87507	a,d	91.4		90296	L6	90053	a,d,f	34.1	
90117	L6	90053	a,d,f	34.1		90175	L6	90157	a,d,f,g	96.9		90235	L6	90053	a,d,f	58.4		90297	L6	90192	a,d,f	80.2	
90118	L6	90053	a,d,f	34.1		90176	L6	90053	a,d,f	34.1		90236	L6	90053	a,d,f	34.1		90298	L6	90192	a,d,f	80.2	
90119	L6	90053	a,d,f	34.1		90177	L6	90071	a,d,f,g	94.8		90239	L6	90053	a,d,f	34.1		90300	L6	90076	a,d,f,g	93.1	
90120	L6	90053	a,d,f	59.9		90180	L6	90053	a,d,f	59.9		90240	L6	90053	a,d,f	34.1		90301	L6	90053	a,d,f	34.1	
90121	L6	90053	a,d,f,g	ref.		90181	L6	90053	a,d,f	59.9		90241	L6	90053	a,d,f	34.1		90302	L6	90053	a,d,f	34.1	
90122	L6	90053	a,d,f	59.9		90182	L6	90053	a,d,f	59.9		90242	L6	90053	a,d,f	34.1		90305	L6	90053	a,d,f	34.1	
90123	L6	90053	a,d,f	59.9		90183	L6	90053	a,d,f	34.1		90243	L6	90053	a,d,f	59.9		90306	L6	90053	a,d,f	34.1	
90124	L6	90053	a,d,f	59.9		90184	L6	90053	a,d,f	59.9		90244	L6	90053	a,d,f	59.9		90307	L6	90053	a,d,f	34.1	
90125	L6	90053	a,d,f	59.9		90185	L6	90053	a,d,f	59.9		90245	L6	90053	a,d,f	34.1		90308	L6	90053	a,d,f	58.4	
90126	L6	90053	a,d,f	59.9		90186	L6	90053	a,d,f	59.9		90249	L6	90053	a,d,f	34.1		90309	L6	90053	a,d,f	59.9	
90127	L6	90053	a,d,f	59.9		90187	L6	90053	a,d,f	59.9		90250	L6	90053	a,d,f	34.1		90310	L6	90053	a,d,f	34.1	
90128	L6	90053	a,d,f	59.9		90188	L6	90053	a,d,f	59.9		90251	L6	90053	a,d,f	34.1		90311	L6	90053	a,d,f	34.1	
90129	L6	90053	a,d,f	59.9		90189	L6	90053	a,d,f	34.1		90252	L6	90053	a,d,f	58.4		90312	L6	90053	a,d,f	34.1	
90130	L6	90053	a,d,f	34.1		90190	L6	90053	a,d,f	59.9		90254	L6	90053	a,d,f	34.1		90314	L6	90053	a,d,f	34.1	
90131	L6	90053	a,d,f	59.9		90191	L6	90053	a,d,f	34.1		90256	L6	90053	a,d,f	34.1		90315	L6	90053	a,d,f	58.4	
90132	L6	90053	a,d,f	34.1		90193	L6	90053	a,d,f	34.1		90257	L6	90053	a,d,f	59.9		90316	L6	90076	a,d,f,g	96.4	
90133	L6	90053	a,d,f	34.1		90194	L6	90053	a,d,f	34.1		90259	L6	90053	a,d,f	34.1		90317	L6	90053	a,d,f	58.4	
90134	L6	90053	a,d,f	34.1		90195	L6	90192	a,d,f	80.2		90260	L6	90053	a,d,f	34.1		90318	L6	90053	a,d,f	58.4	
90135	L6	90053	a,d,f	34.1		90196	L6	90053	a,d,f	59.9		90261	L3.4	90080	a,c,d,f	97.1		90319	L6	90053	a,d,f	34.1	
90136	L6	90053	a,d,f	34.1		90197	L6	90053	a,d,f	59.9		90262	L6	90053	a,d,f	34.1		90320	L6	90053	a,d,f	58.4	
90137	L6	90053	a,d,f	34.1		90198	L6	90053	a,d,f	58.4		90263	L6	90053	a,d,f	34.1		90321	L6	90053	a,d,f	34.1	
90138	L6	90204	a,d,f,g	85.8		90199	L6	90053	a,d,f	34.1		90265	L6	90053	a,d,f	34.1		90322	L6	90053	a,d,f	34.1	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
EET		**EET**			
90323	L6	90053	a,d,f	34.1	
90324	L6	90053	a,d,f	58.4	
90325	L6	90192	a,d,f	80.2	
90326	L6	90053	a,d,f	34.1	
90327	L6	90053	a,d,f	34.1	
90329	L6	90053	a,d,f	34.1	
90331	L6	90192	a,d,f	80.2	
90332	L6	90053	a,d,f	34.1	
90333	L6	90192	a,d,f	80.2	
90334	L6	90053	a,d,f	58.4	
90335	L6	90053	a,d,f	34.1	
90336	L6	90053	a,d,f	34.1	
90337	L6	90053	a,d,f	34.1	
90338	L6	90192	a,d,f	80.2	
90339	L6	90053	a,d,f	34.1	
90340	L6	90053	a,d,f	34.1	
90341	L6	90053	a,d,f	34.1	
90342	L6	90192	a,d,f	80.2	
90343	L6	90053	a,d,f	58.4	
90344	L6	90053	a,d,f	58.4	
90346	L6	90053	a,d,f	58.4	
90347	L6	90053	a,d,f	59.9	
90348	L6	90192	a,d,f	80.2	
90349	L6	90192	a,d,f	80.2	
90350	L6	90053	a,d,f,g	ref.	
90351	L6	90053	a,d,f,g	ref.	
90352	L6	90053	a,d,f	59.9	
90353	L6	90204	a,d,f,g	92.8	
90354	L6	90157	a,d,f,g	97.9	
90355	L6	90204	a,d,f,g	92.8	
90357	L6	90053	a,d,f	58.4	
90358	L6	90053	a,d,f,g	99.1	
90359	L6	90053	a,d,f,g	ref.	
90360	L6	90053	a,d,f	34.1	
90361	L6	90053	a,d,f	34.1	
90362	L6	90157	a,d,f,g	90.3	
90363	L6	90053	a,d,f	34.1	
90364	L6	90157	a,d,f,g	93.1	
90365	L6	90053	a,d,f	34.1	
90366	L6	90157	a,d,f,g	93.1	
90367	L6	90076	a,d,f,g	93.1	
90368	L6	90053	a,d,f	34.1	
90369	L6	90053	a,d,f	34.1	
90370	L6	90053	a,d,f	34.2	
90371	L6	90053	a,d,f	58.4	
90373	L6	90192	a,d,f	80.2	
90374	L6	90053	a,d,f	34.1	
90375	L6	90053	a,d,f	34.1	
90376	L6	90053	a,d,f	34.1	
90377	L6	90152	a,d,f,g	95.1	
90378	L6	90053	a,d,f	59.9	
90379	L6	90053	a,d,f	59.9	
EET		**EET**			
90380	L6	90053	a,d,f	59.9	
90381	L6	90053	a,d,f	59.9	
90382	L6	90053	a,d,f	59.9	
90383	L6	90053	a,d,f	59.9	
90384	L6	90053	a,d,f	59.9	
90385	L6	90053	a,d,f	34.1	
90387	L6	90053	a,d,f	59.9	
90389	L6	90053	a,d,f	59.9	
90390	L6	90053	a,d,f	34.1	
90391	L6	90053	a,d,f,g	ref.	
90392	L6	90053	a,d,f	34.1	
90393	L6	90053	a,d,f	34.1	
90394	L6	90157	a,d,f,g	93.1	
90395	L6	90053	a,d,f	34.1	
90396	L6	90053	a,d,f	34.1	
90397	L6	90053	a,d,f	34.1	
90398	L6	90053	a,d,f	58.4	
90399	L6	90053	a,d,f	34.1	
90400	L6	90053	a,d,f	34.1	
90401	L6	90053	a,d,f	34.1	
90402	L6	90053	a,d,f	34.1	
90403	L6	90053	a,d,f	34.1	
90404	L6	90053	a,d,f	34.1	
90407	L6	90053	a,d,f	58.4	
90408	L6	90053	a,d,f	34.1	
90409	L6	90053	a,d,f	34.1	
90410	L6	90053	a,d,f	34.1	
90411	L6	90053	a,d,f	34.1	
90413	L6	90053	a,d,f	34.1	
90414	L6	90157	a,d,f,g	93.1	
90415	L6	90053	a,d,f	34.1	
90416	L6	90053	a,d,f	34.1	
90417	L6	90053	a,d,f	58.4	
90418	L6	90192	a,d,f	80.2	
90419	L6	90192	a,d,f	80.2	
90420	L6	90053	a,d,f	34.1	
90421	L6	90053	a,d,f	34.1	
90422	L6	90053	a,d,f	59.9	
90423	L6	90053	a,d,f	34.1	
90426	L6	90053	a,d,f	34.1	
90427	L6	90053	a,d,f	34.1	
90428	CK5	87507	a,c,d	91.4	
90429	L6	90053	a,d,f	34.1	
90430	L6	90053	a,d,f	58.4	
90431	L6	90053	a,d,f	59.9	
90432	L6	90192	a,d,f	80.2	
90434	L6	90192	a,d,f	80.2	
90435	L6	90053	a,d,f	34.1	
90436	L6	90053	a,d,f	34.1	
90437	L6	90192	a,d,f	80.2	
90438	L6	90053	a,d,f	58.4	
90439	L6	90053	a,d,f	34.1	
EET		**EET**			
90440	L6	90053	a,d,f	34.1	
90441	L6	90053	a,d,g	ref.	
90442	L6	90053	a,d,f	34.1	
90443	L6	90204	a,d,f,g	88.5	
90444	L6	90053	a,d,f	34.1	
90445	L6	90053	a,d,f	34.1	
90446	L6	90053	a,d,f	34.1	
90447	L6	90053	a,d,f	34.1	
90448	L6	90053	a,d,f	34.1	
90449	L6	90053	a,d,f	34.1	
90450	L6	90053	a,d,f	34.1	
90451	L6	90053	a,d,f	34.1	
90453	L6	90053	a,d,f	34.1	
90454	L6	90356	a,d,f,g	85.8	
90455	L6	90076	a,d,f,g	96.0	
90457	L6	90053	a,d,f,g	ref.	
90458	L6	90053	a,d,f,g	ref.	
90459	L6	90152	a,d,f,g	90.3	
90460	L6	90053	a,d,f	34.1	
90461	L6	90053	a,d,f	34.1	
90462	L6	90053	a,d,f	59.9	
90463	L6	90053	a,d,f	34.1	
90464	L6	90053	a,d,f	58.4	
90465	L6	90157	a,d,f,g	93.1	
90466	L6	90204	a,d,f,g	85.8	
90467	L6	90053	a,d,f	34.1	
90468	L6	90157	a,d,f,g	96.0	
90470	L6	90157	a,d,f,g	93.1	
90471	L6	90053	a,d,f,g	ref.	
90472	L6	90076	a,d,f,g	96.0	
90473	L6	90473	a,d,f	91.4	
90474	L6	90053	a,d,f	58.4	
90475	L6	90053	a,d,f	34.1	
90476	L6	90053	a,d,f	34.1	
90477	L6	90156	a,d,f,g	85.8	
90478	L6	90053	a,d,f	59.9	
90479	L6	90157	a,d,f,g	95.1	
90480	L6	90053	a,d,f	59.9	
90481	L6	90053	a,d,f	34.1	
90482	L6	90053	a,d,f	59.9	
90483	L6	90204	a,d,f,g	92.8	
90484	L6	90053	a,d,f	59.9	
90485	L6	90053	a,d,f	59.9	
90486	L6	90053	a,d,f	59.9	
90487	L6	90204	a,d,f,g	92.8	
90488	L6	90053	a,d,f,g	ref.	
90497	L6	90053	a,d,f	34.1	
90498	L6	90076	a,d,f,g	93.1	
90499	L6	90156	a,d,f,g	88.5	
90500	L6	90076	a,d,f,g	93.1	
90501	L6	90053	a,d,f	34.1	
90503	L6	90053	a,d,f	34.1	
EET		**EET**			
90504	L6	90076	a,d,f,g	93.1	
90505	L6	90490	a,d,f,g	95.1	
90506	L6	90157	a,d,f,g	93.1	
90507	L6	90053	a,d,f	34.1	
90508	L6	90053	a,d,f	34.1	
90509	L6	90053	a,d,f	34.1	
90510	L6	90053	a,d,f	34.1	
90511	L6	90053	a,d,f	34.1	
90511	L6	90053	a,d,f	34.1	
90513	L6	90053	a,d,f	58.4	
90514	L6	90053	a,d,f	34.1	
90515	L6	90053	a,d,f	34.1	
90516	L6	90053	a,d,f	58.4	
90517	L6	90053	a,d,f	34.1	
90518	L6	90192	a,d,f	80.2	
90520	L6	90053	a,d,f	59.9	
90521	L6	90053	a,d,f	34.1	
90522	L6	90053	a,d,f	59.9	
90523	L6	90053	a,d,f	59.9	
90524	L6	90053	a,d,f	59.9	
90526	L6	90053	a,d,f	59.9	
90527	L6	90053	a,d,f	59.9	
90528	L6	90053	a,d,f	59.9	
90529	L6	90053	a,d,f	34.1	
90530	L6	90053	a,d,f	34.1	
90531	L6	90053	a,d,f	34.1	
90532	L6	90053	a,d,f	34.1	
90533	L6	90053	a,d,f	34.1	
90534	L6	90053	a,d,f	58.4	
90535	L6	90053	a,d,f	58.4	
90536	L6	90053	a,d,f	34.1	
90537	L6	90053	a,d,f	34.1	
90538	L6	90053	a,d,f	58.4	
90539	L6	90053	a,d,f	58.4	
90540	L6	90053	a,d,f	59.9	
90541	L6	90053	a,d,f	59.9	
90543	L6	90053	a,d,f	34.1	
90544	L6	90053	a,d,f	59.9	
90545	L6	90053	a,d,f	59.9	
90546	L6	90053	a,d,f	59.9	
90549	L6	90053	a,d,f	34.1	
90550	L6	90053	a,d,f	34.1	
90554	L6	90053	a,d,f	34.1	
90555	L6	90053	a,d,f	58.4	
90556	L6	90192	a,d,f	80.2	
90557	L6	90053	a,d,f	34.1	
90558	L6	90053	a,d,f	34.1	
90559	L6	90053	a,d,f	34.1	
90560	L6	90053	a,d,f	34.1	
90561	L6	90053	a,d,f	58.4	
90562	L6	90053	a,d,f	58.4	
90563	L6	90053	a,d,f	58.4	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
EET		**EET**			
90564	L6	90053	a,d,f	34.1	
90565	L6	90053	a,d,f	34.1	
90580	L6	90053	a,d,f	80.2	
90581	L6	90053	a,d,f	34.1	
90489	L6	90053	a,d,f	59.9	
90491	L6	90157	a,d,f,g	96.6	
90492	L6	90356	a,d,f,g	93.1	
90494	L6	90157	a,d,f,g	96.6	
90496	L6	90053	a,d,f,g	ref.	
90582	L6	90053	a,d,f	80.2	
90583	L6	90192	a,d,f	80.2	
90584	L6	90053	a,d,f	34.1	
90585	L6	90053	a,d,f	34.1	
90586	L6	90192	a,d,f	80.2	
90587	L6	90053	a,d,f	34.1	
90588	L6	90192	a,d,f	80.2	
90589	L6	90053	a,d,f	34.1	
90590	L6	90053	a,d,f	34.1	
90591	L6	90053	a,d,f	34.1	
90592	L6	90192	a,d,f	80.2	
90593	L6	90053	a,d,f	34.1	
90594	L6	90192	a,d,f	80.2	
90595	L6	90192	a,d,f	80.2	
90596	L6	90053	a,d,f	34.1	
90597	L6	90204	a,d,f,g	94.2	
90598	L6	90053	a,d,f	34.1	
90599	L6	90157	a,d,f,g	96.6	
90600	L6	90053	a,d,f	34.1	
90602	L6	90053	a,d,f	59.9	
90603	L6	90053	a,d,f	34.1	
90604	L6	90053	a,d,f	58.4	
90605	L6	90053	a,d,f	34.1	
90606	L6	90053	a,d,f	34.1	
90607	L6	90053	a,d,f	34.1	
90608	L6	90053	a,d,f	34.1	
90609	L6	90053	a,d,f	59.9	
90610	L6	87587	d,f,g	96.0	
90611	L6	90053	a,d,f	79.2	
90612	L6	90053	a,d,f	34.1	
90613	L6	90192	a,d,f	80.2	
90614	L6	90053	a,d,f	34.1	
90615	L6	90053	a,d,f	34.1	
90617	L6	90053	a,d,f	34.1	
90618	L6	90053	a,d,f	34.1	
90619	L6	90053	a,d,f,g	96.0	
90620	L6	90053	a,d,f	34.1	
90621	L6	90053	a,d,f	58.4	
90622	L6	90053	a,d,f	59.9	
90624	L6	90053	a,d,f	34.1	
90625	L6	90053	a,d,f	34.1	
90626	L6	90053	a,d,f	34.1	
90627	L6	90053	a,d,f	34.1	
EET		**EET**			
90629	L6	90053	a,d,f	58.4	
90630	L6	90053	a,d,f	34.1	
90631	L6	90053	a,d,f	34.1	
90632	L6	90053	a,d,f	34.1	
90633	L6	90053	a,d,f	34.1	
90634	L6	90053	a,d,f	34.1	
90635	L6	90053	a,d,f	34.1	
90636	L6	90053	a,d,f	34.1	
90637	L6	90053	a,d,f	34.1	
90638	L6	90053	a,d,f	34.1	
90639	L6	90053	a,d,f	34.1	
90641	L6	90053	a,d,f	34.1	
90642	L6	90053	a,d,f	34.1	
90643	L6	90053	a,d,f	34.1	
90644	L6	90473	a,d,f	91.4	
90645	L6	90207	a,d,f,g	96.0	
90646	L6	90053	a,d,f	34.1	
90647	L6	90053	a,d,f	34.1	
90648	L6	90053	a,d,f	34.1	
90649	L6	90053	a,d,f	34.1	
90651	L6	90053	a,d,f	34.1	
90652	L6	90053	a,d,f	34.1	
90654	L6	90053	a,d,f	34.1	
90655	L6	90053	a,d,f	34.1	
90656	L6	90053	a,d,f	34.1	
90658	L6	90053	a,d,f	59.9	
90660	L6	90053	a,d,f	34.1	
90661	L6	90053	a,d,f	34.1	
90662	L6	90053	a,d,f	34.1	
90663	L6	90053	a,d,f	34.1	
90664	L6	90053	a,d,f	34.1	
90665	L6	90053	a,d,f	34.1	
90667	L6	90053	a,d,f	34.1	
90668	L6	90053	a,d,f	34.1	
90669	L6	90053	a,d,f	34.1	
90670	L6	90053	a,d,f	34.1	
90672	L6	90053	a,d,f	34.1	
90673	L6	90053	a,d,f	58.4	
90674	L6	90053	a,d,f	58.4	
90675	L6	90053	a,d,f	58.4	
90676	L6	90053	a,d,f	58.4	
90677	L6	90053	a,d,f	58.4	
90678	L6	90053	a,d,f	58.4	
90679	L6	90053	a,d,f	58.4	
90680	L6	90053	a,d,f	34.1	
90681	L6	90053	a,d,f	59.9	
90682	L6	90053	a,d,f	34.1	
90683	L6	90053	a,d,f	34.1	
90684	L6	90053	a,d,f	34.1	
90685	L6	90053	a,d,f	58.4	
90686	L6	90053	a,d,f	58.4	
90687	L6	90053	a,d,f	58.4	
EET		**EET**			
90688	L6	90192	a,d,f	80.2	
90689	L6	90053	a,d,f	34.1	
90690	L6	90053	a,d,f	58.4	
90691	L6	90053	a,d,f	58.4	
90692	L6	90053	a,d,f	58.4	
90693	L6	90053	a,d,f	58.4	
90694	L6	90053	a,d,f	58.4	
90695	L6	90053	a,d,f	54.9	
90696	L6	90053	a,d,f	34.1	
90697	L6	90053	a,d,f	58.4	
90698	L6	90053	a,d,f	58.4	
90699	L6	90053	a,d,f	58.4	
90700	L6	90053	a,d,f	59.9	
90701	L6	90053	a,d,f	59.9	
90702	L6	90053	a,d,f	34.1	
90703	L6	90053	a,d,f	34.1	
90704	L6	90053	a,d,f	34.1	
90705	L6	90053	a,d,f	34.1	
90706	L6	90053	a,d,f	59.9	
90708	L6	90053	a,d,f	58.4	
90709	L6	90053	a,d,f	58.4	
90710	L6	90053	a,d,f	59.9	
90711	L6	90053	a,d,f	59.9	
90712	L6	90053	a,d,f	58.4	
90713	L6	90053	a,d,f	58.4	
90714	L6	90053	a,d,f	34.1	
90715	L6	90053	a,d,f	58.4	
90716	L6	90053	a,d,f	58.4	
90717	L6	90053	a,d,f	58.4	
90720	L6	90053	a,d,f	59.9	
90723	L6	90053	a,d,f	34.1	
90724	L6	90053	a,d,f	58.1	
90725	L6	90053	a,d,f	58.1	
90726	L6	90053	a,d,f	58.1	
90727	L6	90053	a,d,f	58.1	
90728	L6	90053	a,d,f	58.1	
90729	L6	90053	a,d,f	58.1	
90730	L6	90053	a,d,f	59.9	
90731	L6	90053	a,d,f	59.9	
90733	L6	90053	a,d,f	58.4	
90734	L6	90053	a,d,f	58.4	
90735	L6	90053	a,d,f	59.9	
90736	L6	90053	a,d,f	59.9	
90737	L6	90053	a,d,f	59.9	
90738	L6	90053	a,d,f	58.4	
90739	L6	90053	a,d,f	59.9	
90740	L6	90053	a,d,f	59.9	
90741	L6	90053	a,d,f	34.1	
90742	L6	90053	a,d,f	58.4	
90743	L6	90053	a,d,f	59.9	
90744	L6	90053	a,d,f	59.9	
90746	L6	90053	a,d,f	59.9	
EET		**EET**			
90747	L6	90053	a,d,f	58.4	
90748	L6	90053	a,d,f	34.1	
90749	L6	90053	a,d,f	34.1	
90750	L6	90053	a,d,f	58.4	
90751	L6	90053	a,d,f	58.4	
90752	L6	90053	a,d,f	58.4	
90753	L6	90053	a,d,f	34.1	
90754	L6	90192	a,d,f	80.2	
90756	L6	90053	a,d,f	58.4	
90758	L6	90053	a,d,f	58.4	
90759	L6	90053	a,d,f	34.1	
90760	L6	90053	a,d,f	34.1	
90761	L6	90053	a,d,f	58.4	
90762	L6	90053	a,d,f	59.9	
90763	L6	90053	a,d,f	34.1	
90764	L6	90053	a,d,f	34.1	
90765	L6	90053	a,d,f	58.4	
90766	L6	90053	a,d,f	58.4	
90767	L6	90053	a,d,f	58.4	
90768	L6	90053	a,d,f	58.4	
90769	L6	90053	a,d,f	58.4	
90770	L6	90053	a,d,f	34.1	
90771	L6	90053	a,d,f	58.4	
90772	L6	90053	a,d,f	58.4	
90773	L6	90053	a,d,f	58.4	
90774	L6	90053	a,d,f	58.4	
90775	L6	90053	a,d,f	34.1	
90776	L6	90053	a,d,f	58.4	
90777	L6	90053	a,d,f	58.4	
90779	L6	90053	a,d,f	34.1	
90780	L6	90053	a,d,f	58.4	
90781	L6	90053	a,d,f	34.1	
90782	L6	90053	a,d,f	34.1	
90783	L6	90053	a,d,f	59.9	
90784	L6	90053	a,d,f	58.4	
90785	L6	90053	a,d,f	34.1	
90786	L6	90053	a,d,f	58.4	
90787	L6	90053	a,d,f	34.1	
90788	L6	90053	a,d,f	58.4	
90789	L6	90053	a,d,f	58.4	
90790	L4	90745	a,d,f	92.9	
90791	L6	90053	a,d,f	34.1	
90792	L6	90053	a,d,f	34.1	
90793	L6	90053	a,d,f	34.1	
90794	L6	90053	a,d,f	59.9	
90795	L6	90053	a,d,f	58.4	
90796	L6	90053	a,d,f	34.1	
90797	L6	90053	a,d,f	59.9	
90798	L6	90053	a,d,f	34.1	
90799	L6	90053	a,d,f	34.1	
90800	L6	90053	a,d,f	58.4	
90801	L6	90053	a,d,f	34.1	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
EET		**EET**			
90802	L6	90053	a,d,f	34.1	
90803	L6	90192	a,d,f	80.2	
90804	L6	90053	a,d,f	58.4	
90805	L6	90053	a,d,f	34.1	
90806	L6	90053	a,d,f	34.1	
90807	L4	90745	a,d,f	92.9	
90808	L6	90053	a,d,f	34.1	
90809	L6	90053	a,d,f	34.1	
90810	L6	90053	a,d,f	34.1	
90811	L6	90053	a,d,f	34.1	
90812	L6	90192	a,d,f	80.2	
90813	L6	90192	a,d,f	80.2	
90814	L6	90053	a,d,f	58.4	
90815	L6	90053	a,d,f	59.9	
90816	L6	90192	a,d,f	80.2	
90817	L6	90192	a,d,f	80.2	
90818	L6	90192	a,d,f	80.2	
90819	L6	90053	a,d,f	58.4	
90820	L6	90053	a,d,f	34.1	
90821	L6	90053	a,d,f	34.1	
90822	L6	90053	a,d,f	58.4	
90823	L6	90053	a,d,f	58.4	
90824	L6	90053	a,d,f	80.2	
90825	L6	90053	a,d,f	58.4	
90826	L6	90053	a,d,f	80.2	
90827	L6	90053	a,d,f	58.4	
90828	L6	90053	a,d,f	58.4	
90829	L6	90053	a,d,f	58.4	
90916	L3.6	90909	a,c,d,f	97.7	
90986	C2	90047	a,c,d	87.3	
90991	CK5	87507	a,c,d	99.1	
90992	EL3	90299	a,c,d	96.5	
92001	Mes	87500	a,c,d,g	ref.	
92002	CK5	87507	a,c,d,g	99.1	
92003	EUC	87542	c,d,g	76.0	
92005	C2	92005	a,d	87.3	
92007	C2	92005	a,d	87.3	
92008	C2	92005	a,d	87.3	
92010	C2	92010	a,d	87.3	
92013	LL7	92013	a,d,f	99.9	
92015	How	92014	a,d	85.7	
92016	LL7	92012	a,d,f	99.9	
92019	LL6	92017	a,d	91.3	
92020	LL6	92017	a,d	93.5	
92021	LL6	92017	a,d	9.3	
92030	L6	87502	d,f,g	95.1	
92032	L6	90156	d,f,g	85.8	
92036	L6	90204	d,f,g	85.7	
92042	CR2	87711	a,d	97.3	
92043	L6	87549	d,f,g	93.9	
92048	CR2	87711	a,d	97.3	
92052	CR2	87711	a,d	97.3	
EET		**EET**			
92059	L6	92055	d,f,g	84.0	
92062	CR2	87711	a,d	97.3	
92065	CR2	92065	a,d	97.3	
92070	CR2	87711	a,d	97.3	
92092	CR2	87711	a,d	97.3	
92094	CR2	87711	a,d	97.3	
92105	CR2	87711	a,c,d	97.3	
92107	CR2	87711	a,d	97.3	
92131	CR2	87711	a,d	97.3	
92136	CR2	87711	a,d	97.3	
92138	CR2	87711	a,d	97.3	
92143	CR2	87711	a,d	97.3	
92144	CR2	87711	a,d	97.3	
92147	CR2	87711	a,d	97.3	
92149	CR2	87711	a,d	97.3	
92150	CR2	87711	a,d	97.3	
92152	CR2	87711	a,d	97.3	
92156	CR2	87711	a,d	97.3	
92159	CR2	87711	a,d	97.3	
92161	CR2	87711	a,d	97.3	
92162	CR2	87711	a,d	97.3	
92163	CR2	87711	a,d	97.3	
92164	CR2	87711	a,d	97.3	
92165	CR2	87711	a,d	97.3	
92166	CR2	87711	a,d	97.3	
92168	CR2	87711	a,d	97.3	
92169	CR2	87711	a,d	97.3	
92171	CR2	87711	a,d	97.3	
92174	CR2	87711	a,d	97.3	
92175	CR2	87711	a,d	97.3	
92176	CR2	87711	a,d	97.3	
92177	CR2	87711	a,d	97.3	
92178	CR2	87711	a,d	97.3	
92179	CR2	87711	a,d	97.3	
92180	CR2	87711	a,d	97.3	
92183	CR2	87711	a,d	97.3	
92185	CR2	87711	a,d	97.3	
92188	CR2	87711	a,d	97.3	
92189	CR2	87711	a,d	97.3	
92190	CR2	87711	a,d	97.3	R
96004	How	96003	a,d	76.7	
96006	C2	96005	a,d	87.3	
96007	C2	96005	a,d	87.3	
96008	Lunar	87521	a,c,d	96.5	AG
96029	C2	96005	a,d	87.3	
96037	H4	96031	a,d,f	89.1	
96040	H4	96031	a,d,f	89.1	
96047	H4	96031	a,d,f	88.7	
EETA		**EETA**			
79001	Euc	79004	d,e	ref.	H,M
79004	Euc	79004	a,c,d,e	ref.	H,M
79011	Euc	79004	a,c,d	ref.	M,P
EETA		**EET**			
82600	Euc	79006	a,d	87.3	P
82606	L6	82605	a,d,f,g	63.3	P
82615	H6	82610	a,d,f	83.8	P
83212	Euc	83212	a,c,d	ref.	M
83227	Euc	83212	a,c,d	ref.	M
83227	Euc	79004	d,e	87.3	H
83227	Euc	79005	a,d	87.3	P
83228	Euc	79004	a,d,e	87.3	H,P
83229	Euc	79004	a,d	87.3	P
83231	Euc	79004	a,d	87.3	P
83232	Euc	79004	a,d	87.3	P
83234	Euc	79004	a,d	87.3	P
83235	Euc	79005	a,d	87.3	P
83238	L6	83206	a,d,f,h	96.2	U
83241	L6	83206	a,d,f,h	63.6	U
83243	L6	83206	a,d,f,h	96.2	U
83246	Diog	83246	a,d	ref.	P
83247	Diog	83246	a,d	ref.	P
83251	Euc	79004	a,d	87.3	P
83252	L6	83206	a,d,h	79.2	U
83254	EH3	83307	a,d	94.1	
83271	L6	83206	a,d,f,h	80.0	U
83283	Euc	79004	a,d	87.3	P
83312	L6	83206	a,d,f,h	63.3	U
83322	EH3	83307	a,d	94.1	
83323	L6	83317	a,d,f	34.1	
83335	L6	83206	a,d,f,h	80.1	U
83342	L6	83317	a,d,f	34.1	
83343	L6	83317	a,d,f	34.1	
83348	L6	83206	a,d,f,h	80.0	U
83355	C2	83226	a,d	87.3	
83363	L6	83206	a,d,h	34.1	U
83376	How	79006	a,d,g	85.7	X
83395	L3.2	83274	a,d,f	97.1	
84304	L6	83206	a,d,f,h	63.3	U
El Djouf		**Acfer**			
1	CR2	97	a,b,d	97.2	AF
1	CR2	59	a,b,d	97.2	C
Forrest		**Forrest**			
7	H4	5	a,d,f	60.7	A
9	L6	8	a,d,f	6.6	A
9	L6	6	a,d,f	6.7	O
13	L6	8	a,d,f	6.6	A
FRO		**FRO**			
90050	H5	90001	a,d,e	73.3	AH
90073	H5	90001	a,d,e	73.3	AH
90087	H5	84003	a,d,e,h	97.0	AH
90107	H5	84003	a,d,e,h	97.0	AH
90152	H5	90001	a,d,e	73.3	AH
90174	H5	84003	a,d,e,h	97.0	AH
90203	H5	84003	a,d,e,h	97.0	AH
90204	H5	84003	a,d,e,h	97.0	AH
FRO		**FRO**			
90211	H5	84003	a,d,e,h	97.0	AH
GRO		**GRO**			
85215	L5	85214	a,d,g	ref.	
85216	L5	85214	a,d,g	ref.	
85217	L5	85214	a,d,f	77.4	
95504	L3	95502	a,d,f,g	99.9	
95505	L3	95502	a,d,f,g	99.9	
95512	L3	95502	a,d,f,g	99.9	
95535	How	95535	a,d	76.6	
95536	L3	95502	a,d,f,g	ref.	
95539	L3	95502	a,d,f,g	99.9	
95542	L3	95502	a,d,f	99.3	
95544	L3	95502	a,d,f,g	99.9	
95545	L3	95502	a,d,f,g	99.9	
95550	L3	95502	a,d,f	99.3	
95574	How	95534	a,d	76.6	
95581	How	95534	a,d	76.6	
95602	How	95534	a,d	76.6	
Hammadah al Hamara					
13	H5	10	a,b,d	89.5	C
23	H5	3	a,b,d	71.4	C
29	H5	3	a,b,d	71.4	C
34	L6	25	a,b,d	73.1	C
35	H5	3	a,b,d	91.2	C
38	L6	26	a,b,d	92.6	C
39	L6	37	a,b,d	96.9	C
40	L6	8	a,b,d	64.8	C
57	LL5–6	52	a,b,d,e,f	99.9	AE
85	LL6	60	a,b,d,e	99.9	AE
Ilafegh		**Ilafegh**			
5	H5	4	a,b,d	89.5	C
11	L5	10	a,b,d	98.5	C
LAP		**LAP**			
91902	L6	91901	a,b,d,f	34.1	
LEW		**LEW**			
85300	Euc	85300	a,c,d,g	87.3	
85302	Euc	85300	a,c,d,g	87.3	
85303	Euc	85300	a,c,d,g	87.3	
85307	C2	85306	a,c,d	87.3	
85309	C2	85306	a,c,d,g	87.3	
85311	C2	85306	a,c,d,g	87.3	
85312	C2	85306	a,c,d	87.3	
85313	How	85313	a,c,d,g	ref.	
85320	H5	85319	a,d,f	85.1	T
85337	H6	85330	d,f,g	98.0	AB
85338	H5	85334	d,f,g	97.4	AB
85355	H5	85316	a,d,f	60.2	
85371	H5	85334	d,f,g	97.4	AB
85379	H5	85341	d,f,g	95.8	AB
85381	H6	85330	d,f,g	98.0	AB
85385	L5	85385	f,g	99.2	
85401	L3.3	85396	a,c,d,f	95.8	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
LEW		**LEW**			
85418	H6	85330	d,f,g	98.0	AB
85427	L6	85325	d,f,g	96.4	AB
85434	L3.4	85434	a,c,d,f	98.6	
85435	H5	85316	a,d,f	60.2	
85437	L3.4	85434	a,c,d,f	98.6	
85440	AUG	85440	a,d	94.7	
85441	How	85313	a,c,d,g	ref.	
85446	H6	85331	d,f,g	98.8	AB
85459	H5	85450	d,f,g	99.3	AB
85464	H5	85464	f,g	95.2	AB
86004	C2	86004	a,c,d	87.3	
86005	C2	86004	a,c,d	87.3	
86007	C2	86004	a,c,d	87.3	
86008	C2	86004	a,c,d	87.3	
86009	C2	86004	a,c,d	87.3	
86013	L6	86011	d,f,g	98.6	AB
86019	L6	85325	d,f,g	96.4	AB
86022	L3.2/3.5	85396	a,d,f	97.7	
86076	H5	86055	d,f,g	92.7	AB
86078	H5	86035	d,f,g	94.8	AB
86081	H5	86035	d,f,g	94.8	AB
86083	H5	86020	d,f,g	93.8	AB
86085	L6	85325	d,f,g	96.4	AB
86102	L3.4	85434	a,b,c,d,f	99.9	
86104	H5	86099	d,f,g	99.0	AB
86105	L3.4	85434	a,b,c,d,f	99.4	
86107	H5	86107	d,f,g	92.7	AB
86110	L6	86073	d,f,g	92.8	AB
86115	L6	86073	d,f,g	92.8	AB
86118	H5	86041	d,f,g	99.3	AB
86127	L3.3	86127	a,c,d,f	97.1	
86134	L3.0	86127	a,c,d,f	97.7	
86144	L3.2	86127	a,c,d,f	97.2	
86158	L3.2	86127	a,c,d,f	97.1	
86166	L6	86090	d,f,g	99.5	AB
86183	H6	86120	d,f,g	98.3	AB
86186	L6	85428	d,f,g	98.8	AB
86203	L6	85428	d,f,g	98.8	AB
86204	H6	85330	d,f,g	98.0	AB
86207	L3.2	86127	a,c,d,f	99.2	
86211	Iron	86211	a,c,d	99.9	
86246	L3.4	86127	a,c,d,f	99.2	
86250	H5	86055	d,f,g	92.7	AB
86268	L6	86428	d,f,g	98.8	AB
86311	L6	85321	d,f,g	93.8	AB
86312	H5	96312	d,f,g	95.8	AB
86366	L3.4	86307	a,c,d,f	97.7	
86371	H5	86047	d,f,g	97.7	AB
86393	H5	86104	d,f,g	90.4	AB
86408	L3.5	86127	a,c,d,f	97.1	
86417	L3.5	86127	a,c,d,f	97.1	
86418	H5	86418	d,f,g	99.5	AB
LEW		**LEW**			
86436	L3.5	86127	a,b,c,d,f	97.1	
86438	H5	86035	d,f,g	94.8	A
86442	H5	86047	d,f,g	97.7	AB
86451	H5	86385	d,f,g	96.2	AB
86485	H5	86463	d,f,g	92.7	AB
86490	L6	86238	d,f,g	97.9	AB
86498	Iron	86211	a,c,d	99.9	
86500	H5	86020	d,f,g	93.8	AB
86505	L3.4	86127	a,c,d,f	ref.	
86525	H5	85405	d,f,g	98.3	AB
86546	L6	86238	d,f,g	97.9	AB
87001	CM2	87001	a,c,d	87.3	
87003	CM2	87001	a,c,d	87.3	
87005	How	87005	a,d	85.7	
87008	CM2	87001	a,d	87.3	
87011	Aub	87007	a,c,d	91.3	
87013	Aub	87007	a,c,d	91.3	
87015	How	87005	a,c,d	85.7	
87017	Aub	87007	a,c,d	91.3	
87018	Aub	87007	a,c,d	91.3	
87019	Aub	87007	a,c,d	91.3	
87020	Aub	87007	a,c,d	91.3	
87021	Aub	87007	a,c,d	91.3	
87022	CM2	87001	a,c,d	87.3	
87025	CM2	87001	a,d	87.3	
87027	CM2	87001	a,d	87.3	
87028	CM2	87001	a,d	87.3	
87042	L6	87035	d,f,g	85.9	AB
87046	L6	87045	d,f,g	88.7	AB
87053	How	87005	a,c,d	85.7	
87056	Aub	87007	a,c,d	91.3	
87057	E3–Anom	87057	a,c,d	96.0	
87167	CM2	87001	a,d	87.3	
87220	E3–Anom	87057	a,c,d	96.0	
87223	E3–Anom	87057	a,c,d	96.0	
87234	E3–Anom	87057	a,c,d	96.0	
87237	E3–Anom	87057	a,c,d	96.0	
87249	CM2	87001	a,c,d	87.3	
87250	CK4	87214	a,c,d	99.1	
87285	E3–AN	87057	a,c,d	96.0	
87294	Aub	87007	a,c,d	91.3	
88002	C2	88001	a,c,d	87.3	
88003	C2	88001	a,c,d	87.3	
88005	Euc	85300	d,g	76.0	
88012	Aug	85440	a,c,d	94.7	
88018	L6	88015	d,f,g	95.1	
88020	H4	88019	a,d,f,g	98.8	
88201	Ure	85440	a,c,d	94.7	
88261	L3.4	88254	a,c,d,f	97.1	
88263	L3.4	88254	a,c,d,f	97.7	
88281	Ure	85440	a,c,d	94.7	
LEW		**ALHA**			
88516	Sher	77005	a,c,d,e,h	ref.	E
LEW		**LEW**			
88586	LL6	88564	a,d,f	91.3	
88608	LL6	88564	a,d,f	91.3	
88714	EL6	88135	a,c,d	93.0	
93800	L5	85385	fg	98.5	
93802	H5	85464	fg	96.6	
LON		**LON**			
94102	C2	94101	a,c,d	87.3	
MAC		**MAC**			
87301	C2	87300	a,c,d,g	87.3	J
87303	L4	87302	a,d,f,g	99.9	
88105	Lunar	88104	a,b,c,d,e,g,h	99.9	L
88107	C2	87300	a,c,d,g	87.3	J
88120	H5	88103	d,f,g	91.9	
88121	L6	88117	d,f,g	98.0	
88131	H6	88130	a,c,f	83.8	
88132	H6	88130	a,d,f,g	98.7	
88133	H6	88130	a,d,f,g	98.7	
88138	H5	88135	d,f,g	95.7	
88139	H5	88135	d,f,g	95.7	
88146	H4	88145	a,d,f	80.0	
88147	H5	88147	d,f,g	99.1	
88164	H5	88147	d,f,g	99.1	
88180	EL3	88136	a,c,d	93.0	
88181	L6	88159	d,f,g	95.1	
88184	EL3	88136	a,c,d	93.0	
88193	L6	88159	d,f,g	95.1	
88197	L6	88159	d,f,g	95.1	
88204	H5	88203	a,d,f	59.8	
MBRA		**MBRA**			
76002	H6	76001	a,d,f	83.8	
MCY		**MCY**			
92052	C2	92500	a,c,d,f	87.3	P
Mundrabilla		**Forrest**			
007	L6	8	a,d,f	6.7	A
Mundrabilla		**Old Homestead**			
020	How	001	a,d	76.7	AI
Nullarbor		**Forest**			
004	L6	6	a,d,f	6.7	O
018	L6	6	a,d,f	6.7	O
PAT		**PAT**			
91505	L6	91503	a,d,f	34.1	
91507	L6	91503	a,d,f	59.9	
91510	L6	91503	a,d,f	34.1	
91511	L6	91503	a,d,f	34.1	
91513	L6	91503	a,d,f	59.9	
PCA		**PCA**			
61608	L6	91009	a,d,f	34.1	
82505	L5	82504	a,d,f	77.4	
91002	R	91002	a,c,d	99.9	
91005	PAL	91004	a,c,d	96.5	
PCA		**PCA**			
91010	L6	91009	a,d,f,g	98.0	
91012	L5	91011	a,d,f	97.5	
91013	L5	91011	a,d,f	97.5	
91016	L6	91009	a,d,f,g	98.0	
91017	L6	91009	a,d,f,g	98.0	
91018	L6	91009	a,d,f,g	98.0	
91021	L6	91009	a,d,f,g	98.0	
91029	L6	91009	a,d,f	34.1	
91032	L5	91030	d,f,g	99.9	
91033	L5	91027	d,f,g	99.6	
91035	L6	91009	a,d,f	34.1	
91036	L5	91028	d,f,g	99.9	
91037	L6	91009	a,d,f	34.1	
91042	L6	91009	a,d,f	34.1	
91044	L5	91028	d,f,g	99.9	
91045	L6	91009	a,d,f	34.1	
91046	L5	91028	d,f,g	99.9	
91047	L6	91009	a,d,f	34.1	
91048	L6	91009	a,d,f	34.1	
91050	L5	91027	d,f,g	99.8	
91053	L5	91028	d,f,g	99.9	
91056	L5	91027	d,f,g	99.7	
91059	L5	91028	d,f,g	99.9	
91060	L5	91028	d,f,g	99.9	
91061	L6	91009	a,d,f	34.1	
91064	L6	91009	a,d,f	34.1	
91066	L5	91028	d,f,g	99.9	
91069	L5	91028	d,f,g	99.9	
91070	L6	91009	a,d,f	34.1	
91073	L5	91028	d,f,g	99.9	
91079	Euc	91079	a,c,d	87.3	
91081	Euc	82502	a,c,d	87.3	
91083	Euc	82502	a,c,d	87.3	
91084	C2	91084	a,c,d	87.3	
91085	EH3	82518	a,c,d	97.0	
91087	L6	91009	a,c,d,f	34.1	
91089	L6	91009	a,c,d,f	34.1	
91095	L6	91009	a,c,d,f	34.1	
91096	L6	91009	a,c,d,f	34.1	
91099	L6	91009	a,c,d,f	34.1	
91102	L6	91009	a,b,d,f	34.1	
91105	L6	91009	a,b,d,f	34.1	
91110	L6	91009	a,b,d,f	34.1	
91112	L6	91009	a,b,d,f	34.1	
91113	L6	91009	a,b,d,f	34.1	
91114	EH3	82518	a,c,d	97.0	
91119	EH3	82518	a,c,d	97.0	
91125	EH3	82518	a,c,d	97.0	
91127	EH3	82518	a,c,d	97.0	
91128	L6	91128	a,d,f	34.1	
91129	EH3	82518	a,c,d	97.0	
91145	L6	91009	a,d,f	34.1	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.	Name	Class	Pairing Group	Pairing Basis	Score	Ref.
PCA		**PCA**				**QUE**		**QUE**				**QUE**		**QUE**				**QUE**		**QUE**			
91147	C2	91084	a,c,d	87.3		90216	L5	90201	a,d,f,g	99.1		90285	L5	90205	a,d,f,g	99.4		93073	L5	90201	a,d,f	80.5	
91159	Euc	91079	a,c,d	87.3		90217	L5	90205	a,d,f,g	99.4		90286	L5	90201	a,d,f	77.4		93074	L5	90201	a,d,f	77.4	
91178	L6	91009	a,d,f	34.1		90219	L5	90201	a,d,f,g	99.1		93001	Mes	86900	a,c,d,g	ref.		93076	L5	90207	a,d,f,g	98.5	
91188	L6	91009	a,d,f	34.1		90221	L5	90205	a,d,f,g	99.8		93002	Mes	86900	a,d	93.0		93077	L5	90201	a,d,f	77.4	
91189	L6	91009	a,d,f	34.1		90224	L5	90205	a,d,f,g	99.4		93006	C2	93004	a,c,d	87.3		93078	L5	90201	a,d,f	88.5	
91193	Euc	91079	a,c,d	87.3		90225	L5	90201	a,d,f,g	99.1		93012	H6	90223	d,f,g	96.5		93082	L5	90201	a,d,f	88.5	
91203	C2	91084	a,c,d	87.3		90226	L5	90205	a,d,f,g	99.4		93014	H6	90223	d,f,g	96.5		93083	H4	93081	a,d,f	89.1	
91209	L6	91009	a,d,f	34.1		90227	L5	90205	a,d,f,g	99.9		93015	L6	87400	d,g	98.2		93084	H4	93081	a,d,f	89.1	
91211	L5	91067	d,f,g	99.9		90229	L5	90201	a,d,f,g	99.1		93017	C2	93004	a,c,d	87.3		93087	L5	90201	a,d,f	80.5	
91214	L6	91009	a,d,f	34.1		90238	L5	90205	a,d,f,g	99.4		93018	C2	93005	a,c,d	87.3		93092	L5	90201	a,d,f	80.5	
91220	L6	91009	a,d,f	34.1		90239	L5	90218	a,d,f,g	98.9		93020	L5	90201	a,d,f,g	99.1		93095	L5	90201	a,d,f	80.5	
91238	EH3	82518	a,c,d	87.3		90240	L5	90205	a,d,f,g	99.5		93031	L5	90207	a,d,f,g	99.4		93096	L5	90201	a,d,f	77.4	
91239	H5	91040	a,d,f	85.1		90241	L5	90201	a,d,f,g	99.1		93032	L5	90205	a,d,f,g	99.5		93108	L5	90201	a,d,f	80.5	
91241	R	91002	a,c,d	99.1		90242	L5	90205	a,d,f,g	99.4		93033	H5	93029	d,f,g	96.5		93109	L5	90201	a,d,f	80.5	
91245	Euc	91078	a,c,d	87.3		90243	L5	90201	a,d,f,g	99.4		93035	L5	90207	a,d,f,g	99.1		93112	L5	90201	a,d,f	88.5	
91250	L6	91009	a,c,d,f	63.3		90244	L5	90201	a,d,f,g	99.4		93036	L5	90207	a,d,f,g	99.1		93113	L5	90201	a,d,f	77.4	
91251	L6	91009	a,c,d,f	63.3		90245	L5	90201	a,d,f,g	99.1		93037	L5	90205	a,d,f,g	99.4		93116	L5	90201	a,d,f	77.4	
91254	EH3	82518	a,c,d	87.3		90246	L5	90201	a,d,f,g	99.4		93038	H5	93029	a,d,g	ref.		93118	L5	90201	a,d,f	77.4	
91258	EH3	82518	a,c,d	87.3		90247	L5	90205	a,d,f,g	99.9		93039	L5	90207	a,d,f,g	99.1		93119	L5	90201	a,d,f	80.5	
91267	H6	91026	d,f,g	99.3		90248	L5	90201	a,d,f,g	99.4		90230	L5	90201	a,d,f,g	98.5		93120	L5	90201	a,d,f	77.4	
91276	L6	91009	a,d,f	58.4		90249	L5	90205	a,d,f,g	99.9		90231	L5	90201	a,d,f,g	99.4		93123	L5	90201	a,d,f	77.4	
91284	L6	91009	a,c,d,f	34.1		90250	L5	90201	a,d,f,g	99.1		90232	L5	90201	a,d,f,g	99.4		93126	Mes	86900	a,c,d	93.0	
91293	L6	91009	a,c,d,f	34.1		90251	L5	90205	a,d,f,g	ref.		90233	L5	90201	a,d,f,g	99.4		93127	L5	90201	a,d,f	77.4	
91298	EH3	82518	a,d	97.0		90252	L5	90201	a,d,f,g	99.1		90234	L5	90201	a,d,f,g	99.4		93128	L5	90201	a,d,f	88.5	
91300	EH3	82518	a,d	97.0		90253	L5	90201	a,d,f	85.8		90235	L5	90201	a,d,f,g	98.5		93150	Mes	86900	a,c,d	93.0	
91303	EH3	82518	a,d	97.0		90254	L5	90201	a,d,f,g	99.4		90236	L5	90205	a,d,f,g	99.7		93197	L5	90205	d,f,g	99.3	
91383	EH3	82518	a,c,d	94.1		90256	L5	90201	a,d,f	85.8		90237	L5	90201	a,d,f,g	99.4		93216	L5	90201	d,f	98.8	
91388	PAL	91004	a,d	96.5		90257	L5	90201	a,d,f,g	99.1		93040	L5	90207	a,d,f,g	98.5		93231	L5	90205	d,f,g	99.3	
91398	EH3	82518	a,c,d	97.0		90258	L5	90201	a,d,f,g	99.4		93041	L5	90205	a,d,f,g	99.1		93245	L5	90201	d,f,g	99.0	
91444	EH3	82518	a,c,d	97.0		90259	L5	90201	a,d,f,g	99.1		93042	L5	90207	a,d,f,g	99.1		93247	L5	90205	d,f,g	99.7	
91451	EH3	82518	a,c,d	97.0		90260	L5	90201	a,d,f,g	99.4		93043	H5	93029	a,d,f,g	98.5		93251	L5	90201	d,f,g	99.2	
91452	CH	91328	a,c,d	99.9		90261	L5	90205	a,d,f,g	99.4		93044	L5	90207	a,d,f,g	99.4		93307	L5	90201	d,f,g	98.2	
91461	EH3	82518	a,c,d	94.4		90263	L5	90205	a,d,f,g	99.7		93045	L5	90218	a,d,g	ref.		93330	L5	90205	d,f,g	99.3	
91467	CH	91328	a,c,d	99.9		90264	L5	90205	a,d,f,g	99.1		93047	L5	90201	a,d,f	77.4		93341	Ure	93336	a,c,d	94.7	
91475	EH3	82518	a,d	94.1	B	90265	L5	90201	a,d,f	77.4		93048	L5	90201	a,d,f	77.4		93370	L5	90201	d,f,g	99.0	
91477	EH3	82518	a,d	94.1		90266	L5	90201	a,d,f	77.4		93049	H5	93029	a,d,f,g	98.1		93517	Mes	86900	a,c,d	93.0	
91481	EH3	82518	a,d	94.1		90267	L5	90205	a,d,f,g	99.4		93051	H5	93028	d,f,g	98.5		93523	E4	93513	a,c,d	92.0	
PRE		**PRE**				90268	L5	90201	a,d,f	77.4		93052	L5	90207	a,d,f,g	99.1		93575	Mes	86900	a,c,d	93.0	
95411	R	95410	a,d	99.1		90269	L5	90201	a,d,f	77.4		93053	L5	90205	a,d,f,g	99.1		93584	Mes	86900	a,c,d	93.0	
95412	R	95410	a,d	99.1		90270	L5	90201	a,d,f	77.4		93054	L5	90205	a,d,g	99.4		93586	Mes	86900	a,c,d	93.0	
QUE		**QUE**				90271	L5	90205	a,d,f,g	99.1		93056	L5	90207	a,d,f,g	99.1		93600	L5	90205	d,f,g	99.5	
90202	L5	90201	a,d,f,g	98.3		90272	L5	90201	a,d,f,g	98.5		93057	L5	90202	a,d,f,g	99.1		93639	CV3	93429	a,c,d	93.9	
90206	L5	90205	a,d,f,g	99.6		90273	L5	90201	a,d,f	77.4		93058	L5	90207	a,d,f,g	99.1		93683	L5	90201	d,f,g	99.6	
90207	L5	90201	a,d,f,g	99.1		90274	L5	90201	a,d,f	77.4		93059	L5	90207	a,d,f,g	99.1		93696	L5	90201	d,f,g	99.6	
90208	L5	90201	a,d,f,g	99.1		90275	L5	90201	a,d,f	80.5		93061	L5	90207	a,d,f,g	98.5		93699	L5	90205	d,f,g	99.1	
90209	L5	90201	a,d,f,g	98.9		90278	L5	90201	a,d,f	77.4		93062	L5	90205	a,d,f,g	99.7		93706	L5	93216	d,f,g	97.5	
90210	L5	90205	a,d,f,g	99.4		90279	L5	90201	a,d,f	77.4		93063	L5	90202	a,d,f,g	98.5		93707	L5	90205	d,f,g	99.5	
90211	L5	90205	a,d,f,g	99.4		90280	L5	90201	a,d,f	92.9		93065	L5	90205	a,d,f,g	99.7		93744	CV3	93429	a,c,d	93.8	
90212	L5	90205	a,d,f,g	99.7		90281	L5	90201	a,d,f	77.4		93067	L5	90201	a,d,f	77.4		94203	L6	94202	a,d,f	59.5	
90213	L5	90201	a,d,f,g	99.1		90282	L5	90201	a,d,f,g	99.4		93068	L5	90201	a,d,f	77.4		94205	L6	94202	a,d,f	59.9	
90214	L5	90201	a,d,f,g	99.1		90283	L5	90201	a,d,f,g	99.4		93070	L5	90201	a,d,f	77.4		94206	L6	94202	a,d,f	59.9	
90215	L5	90201	a,d,f,g	99.1		90284	L5	90201	a,d,f	77.4		93072	L5	90201	a,d,f	80.5		94207	L6	94202	a,d,f	59.9	

TABLE 1A. *Continued.*

Name	Class	Pairing Group	Pairing Basis	Score	Ref.
QUE		**QUE**			
94208	L6	94202	a,d,f	34.1	
94209	L6	94202	a,d,f	58.4	
94210	L6	94202	a,d,f	34.1	
94211	L6	94202	a,d,f	59.5	
94213	L6	94202	a,d,f	59.5	
94214	L6	94202	a,d,f	58.4	
94215	L6	94202	a,d,f	59.5	
94216	L6	94202	a,d,f	58.4	
94220	C2	94220	a,c,d	87.2	
94222	C2	94220	a,c,d	87.2	
94227	L6	94202	a,d,f	59.5	
94228	L6	94202	a,d,f	34.1	
94231	L6	94202	a,d,f	58.4	
94233	L6	94202	a,d,f	59.9	
94234	L6	94202	a,d,f	59.9	
94235	L6	94202	a,d,f	34.1	
94236	L6	94202	a,d,f	59.5	
94238	L6	94202	a,d,f	59.5	
94239	L6	94202	a,d,f	59.5	
94241	L6	94202	a,d,f	59.5	
94269	Lunar	93069	a,c,d	99.9	
94321	EL3	93351	a,c,d	93.0	
94546	CV3	94366	a,c,d	93.9	
94594	EL3	93351	a,c,d	93.0	
94613	Ure	93336	a,c,d	94.7	
94614	Mes	86900	a,c,d	93.0	
94627	Iron	94411	a,c,d	83.4	
94639	Mes	86900	a,c,d	93.0	
94688	CV3	93429	a,c,d	93.9	
RC		**RC**			
6	L6	4	a,d	33.5	Q
13	H5	12	a,d	46.4	Q
16	H5	12	a,d	46.4	Q
24	H5	8	a,d	46.4	Q
28	L5	25	a,d	68.0	Q
31	H3	1	a,d	96.7	Q
34	H5	32	a,b,d	46.4	S
39	H5	32	a,b,d	46.4	S
40	H5	32	a,b,d	46.4	S
42	H5	32	a,b,d	46.4	S
50	LL4	49	a,b,d	95.1	S
52	H5	32	a,b,d	46.4	S
55	H5	54	a,b,d	46.4	S
69	L5	68	a,d	88.1	N
Reid		**Forest**			
2	L6	6	a,d,f	6.7	O
7	L6	6	a,d,f	6.7	O
Reid		**Reid**			
8	L6	2	a,d,f	6.7	A
RKP		**RKP**			
92404	LL6	86704	d,f,g	99.8	
92416	LL3.7	92413	a,c,d,f	98.5	
RKPA		**RKPA**			
78003	L6	78001	a,d,f,h	97.1	P
79001	L6	78001	a,d,f,h	97.1	P
79002	L6	78001	a,d,f,h	90.8	P
80202	L6	78001	a,d,f,g,h	ref.	P
80206	H6	80203	a,d,f	73.7	P
80208	H6	80203	a,d,f	83.8	P
80211	H6	80203	a,d,f	74.7	P
80213	H6	80203	a,d,f	70.0	P
80214	H6	80203	a,d,f	73.7	P
80218	H5	80217	a,d,f	60.2	P
80219	L6	78001	a,d,f,h	63.3	P
80221	H6	80203	a,d,f	73.7	P
80223	H5	80220	a,d,f	60.2	P
80225	L6	78001	a,d,f	80.2	P
80228	L5	80209	a,d,f	97.5	P
80229	Mes	79015	a,c,d	93.0	P
80231	H6	80203	a,d,f,h	85.2	P
80238	LL6	80222	a,d,f	89.3	P
80242	L4	80216	a,d,f	95.0	P
80246	Mes	79015	a,c,d	93.0	P
80248	LL6	80222	a,d,f	89.3	P
80251	H5	80250	a,d,f	74.2	P
80252	L6	78001	a,d,f	59.9	P
80254	H6	80203	a,d,f,h	73.7	P
80255	H6	80203	a,d,f	73.7	P
80258	Mes	79015	a,d	93.0	P
80261	L6	78001	a,d,f	34.1	P
80262	H6	80203	a,d,f,h	ref.	P
80263	Mes	79015	a,c,d	93.0	P
80264	L6	78001	a,d,f,h	ref.	
80265	H6	80203	a,d,f	73.7	P
80266	H6	80203	a,d,f	70.0	P
80267	H4	80237	a,d,f,h	93.2	P
80268	L5	80209	a,d,f	88.5	P
86700	L3.0/3.9	80256	a,d,f	97.1	
Sahara		**Sahara**			
97079	EH3	97072	a,d	92.2	AI
97081	EH3	97072	a,d	92.2	AI
97086	EH3	97072	a,d	92.2	AI
97088	EH3	97072	a,d	92.2	AI
97089	EH3	97072	a,d	92.2	AI
97090	EH3	97072	a,d	92.2	AI
97091	EH3	97072	a,d	92.2	AI
97092	EH3	97072	a,d	92.2	AI
97093	EH3	97072	a,d	92.2	AI
97098	EH3	97072	a,d	92.2	AI
97101	EH3	97072	a,d	92.2	AI
Sahara		**Sahara**			
97103	EH3	97072	a,d	92.2	AI
97105	EH3	97072	a,d	92.2	AI
97106	EH3	97072	a,d	92.2	AI
97107	EH3	97072	a,d	92.2	AI
97108	EH3	97072	a,d	92.2	AI
97113	EH3	97072	a,d	92.2	AI
97114	EH3	97072	a,d	92.2	AI
97115	EH3	97072	a,d	92.2	AI
97116	EH3	97072	a,d	92.2	AI
97117	EH3	97072	a,d	92.2	AI
97118	EH3	97072	a,d	92.2	AI
97120	EH3	97072	a,d	92.2	AI
97121	EH3	97072	a,d	92.2	AI
97122	EH3	97072	a,d	92.2	AI
97123	EH3	97072	a,d	92.2	AI
97124	EH3	97072	a,d	92.2	AI
97125	EH3	97072	a,d	92.2	AI
97126	EH3	97072	a,d	92.2	AI
97127	EH3	97072	a,d	92.2	AI
97129	EH3	97072	a,d	92.2	AI
97130	EH3	97072	a,d	92.2	AI
97131	EH3	97072	a,d	92.2	AI
97132	EH3	97072	a,d	92.2	AI
97145	EH3	97072	a,d	92.2	AI
97146	EH3	97072	a,d	92.2	AI
97147	EH3	97072	a,d	92.2	AI
97148	EH3	97072	a,d	92.2	AI
97150	EH3	97072	a,d	92.2	AI
97151	EH3	97072	a,d	92.2	AI
97158	EH3	97072	a,d	92.2	AI
97159	EH3	97072	a,d	92.2	AI
97161	EH3	97072	a,d	92.2	AI
97162	EH3	97072	a,d	92.2	AI
97164	EH3	97072	a,d	92.2	AI
97165	L5	97165	a,b,d,f	98.7	AI
97166	EH3	97072	a,d	92.2	AI
97167	EH3	97072	a,d	92.2	AI
97168	EH3	97072	a,d	92.2	AI
97169	EH3	97072	a,d	92.2	AI
97171	L5	97165	a,b,d,f	98.7	AI
97172	L5	97165	a,b,d,f	98.7	AI
97175	L5	97165	a,b,d,f	98.7	AI
97182	L5	97165	a,b,d,f	98.7	AI
97184	L5	97165	a,b,d,f	97.3	AI
97186	L5	97165	a,b,d,f	98.7	AI
97187	L5	97165	a,b,d,f	98.7	AI
97190	L5	97165	a,b,d,f	98.7	AI
97191	H5	97174	a,b,d,f	93.7	AI
97192	L5	97165	a,b,d,f	98.7	AI
Tanezrouft		**Tanezrouft**			
17	H5	7	a,b,d	82.2	C
35	H5	35	a,b,d	97.2	C
39	L3	38	a,b,d	99.9	C
40	L3.9	38	a,b,d	99.9	C
41	L3.8	38	a,b,d	99.9	C
42	L3.7	38	a,b,d	99.9	C
44	H4	43	a,b,d	91.9	C
45	H4	43	a,b,d	91.9	C
46	H5	35	a,b,d	91.9	C
52	H4	9	a,b,d	71.4	C
87	H5	7	a,b,d	97.8	C
TIL		**TIL**			
82413	H5	82412	a,d,f	60.2	P
82415	H5	82414	a,d,f	94.1	P
91701	L4	91700	a,d,f	95.0	
91703	L4	91700	a,d,f	95.0	
91704	L4	91702	a,d,f,g	99.5	
91708	L4	91705	a,d,f,g	99.7	
91709	L4	91700	a,d,f	97.2	
91711	L4	91700	a,d,f	95.0	
91712	L4	91700	a,d,f	95.0	
91718	L4	91702	a,d,f,g	99.5	
91720	L4	91700	a,d,f	95.0	
91721	L4	91705	a,d,f,g	99.4	
91723	L4	91700	a,d,f	95.0	
WIS		**WIS**			
91605	L4	91603	d,f,g	99.9	
91608	C2	91600	a,c,d	87.3	
91628	L6	91626	d,f,g	91.5	
Yamato		**Yamato**			
74450	Euc	74159	a,b,d,e,h	99.9	Z
75011	Euc	74159	a,b,d	76.0	Z
75015	Euc	74159	a,b,d	76.0	Z
82192	Lunar	82192	a,b,c,d,e,h	99.9	K
82192	Lunar	82192	a,b,d,e,h	99.9	F
82193	Lunar	82192	a,b,c,d,e,h	99.9	K
82193	Lunar	82192	a,b,d,e,h	99.9	F
86032	Lunar	82192	c,d,e,h	ref.	K
790007	Euc	74159	a,b,d,e,h	99.9	Z
790020	Euc	74159	a,b,d	76.0	Z
790266	Euc	790260	a,b,d,e,h	99.8	Z
791208	How	790727	a,b,d	85.7	Z
791492	How	790727	a,b,d	85.7	Z
791811	EH4	791810	a,b,d	94.0	AD
791812	EH4	791810	a,b,d	94.0	AD
791962	Euc	791960	a,b,d	76.0	Z
792510	Euc	791186	a,b,d,e,h	99.8	Z
793163	E	792959	a,b,d	89.1	AD

Classification abbreviations: Acap = acapulcoite; Euc = eucrite; How = howardite; Ure = ureilite; Mes = mesosiderite; PAL = pallasite; Anom = anomalous.
Pairing-basis categories: a = petrographic; b = shock classification; c = mineral/bulk composition; d = geographic proximity; e = cosmic-ray exposure age; f = weathering; g = natural thermoluminescence; h = terrestrial age. Underlined = data do not support pairing. Total score is a relative degree of certainty, using $n = 9$ (Eq. 4); "ref" = refuted pairing.
Pairings without citation are from the *Antarctic Meteorite Newsletter*, summarized in the compilations of Grossman (1994), Grossman and Score (1996), and Grossman (1998). Other references: A = Bevan and Binns (1989). B = Bevan and Grady (1988). C = Bischoff and Geiger (1995). D = Bischoff *et al.* (1992). E = Lindstrom *et al.* (1992); Bogard and Garrison (1993). F = Eugster (1987). G = Grossman (1994). H = Herpers *et al.* (1987). I = Hewins (1988). J = Sears *et al.* (1990); Kallemeyn (1992). K = Koeberl (1988); Eugster and Niedermann (1988). L = Korotev *et al.* (1990); Sears *et al.* (1990); Murty and Goswani (1991). M = Okulewicz and Delaney (1986). N = Pun *et al.* (1990). O = Ruzicka (1995). P = Scott (1984a). Q = Scott *et al.* (1986b). R = Sears *et al.* (1990). S = Sipiera *et al.* (1987). T = Vogt *et al.* (1989). U = Wacker (1993). V = Schultz *et al.* (1991). W = Scott (1984b). X = Sears *et al.* (1991). Y = Benoit *et al.* (1993). Z = Takeda (1991). AA = Benoit *et al.* (1994). AB = Benoit *et al.* (1992). AC = Nishiizumi *et al.* (1989). AD = Keil (1989). AE = Scherer *et al.* (1998). AF = Bischoff *et al.* (1993). AG = Lindstrom *et al.* (1999); Snyder *et al.* (1999); Warren and Ulff-Møller (1999). AH = Welten *et al.* (1999). AI = Grossman (1998).