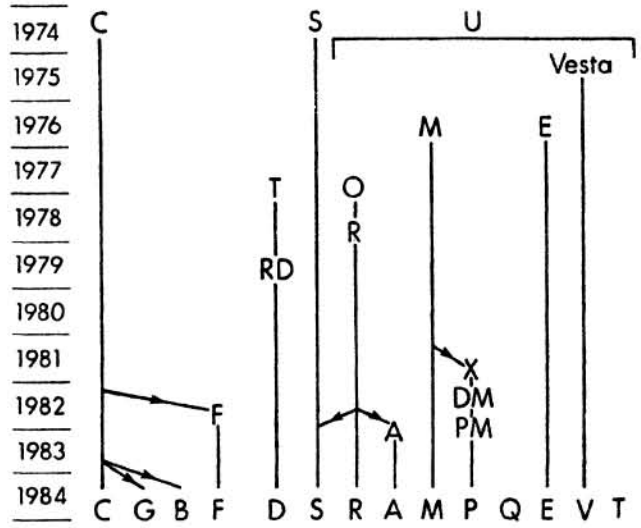
EVOLUTION OF ASTEROID TAXONOMY. D. J. Tholen (Institute for Astronomy, Univ. of Hawaii, Honolulu HI 96822) and J. F. Bell (Hawaii Institute of Geophysics, Univ. of Hawaii, Honolulu HI 96822).

Massive confusion exists in the meteorite community as to the meaning of the lettered "spectral classes" or "taxonomic types" used by asteroid observers to designate groups of asteroids with similar surface composition. Much of this confusion is due to frequent changes in the designations, as the body of observational data grows. This abstract is intended to serve as a historical guide to the asteroid literature for the perplexed.



The first actual asteroid taxonomy as we know it today was generated in 1975 (1) based on a synthesis of polarimetry, radiometry, and spectrophotometry for a sample of 110 asteroids. Only two classes were formally recognized, C and S, although several unusual spectra were designated U.

A unique high-albedo object, 44 Nysa, was identified by the polarimetric method (2). This discovery led to the addition of a new class designated E (3,4). At the same time, some of the unusual moderate-albedo objects recognized, but not classified, in the earlier taxonomy were given the designation M.

A revised taxonomy was published in 1977 (5). Class O was assigned to a few asteroids with spectra that resembled those of ordinary chrondrites. The unique low albedos and comparatively blue colors of the Trojan asteroids were formally recognized by classifying them as T types. In a variation on previous versions of the asteroid taxonomy, U was reserved for unusual objects known to fall outside the domains of the other classes, and I (indeterminate) was assigned to objects with inadequate data to permit a choice from among the several possible classifications. These new classes were short-lived, however. Another revision was made the following year (6). Classes O and T were eliminated, and a new R class was introduced for those objects with the reddest UBV colors. This system was later extended to 752 objects (7).

Observations of a few faint outer-belt asteroids showed that they have distinctly reddish colors, as measured through broad-band red and near-infrared filters, as well as comparatively blue UBV colors, and very low albedos (8). This class was first given the designation RD ("reddish and dark"), defined as consisting of those objects with V-I colors in excess of 0.9. Although a low albedo is also a requirement, no specific upper limit was set for RD status. Because all other classes had single-letter designations and R was already in use, the RD class later became the D class (9).

At about this time the eight-color photometric survey of asteroids began. A new radiometric survey was initiated in parallel with the eight-color work. The two new sources of data were used in 1982 (9) to perform a preliminary examination of the heliocentric distributions of the classes. Two new letter designations were introduced, F and P. The F asteroids had spectra that were either flat (hence the F) or slightly bluish. P asteroids had spectra indistinguishable from those of M asteroids, yet they had low albedos, clearly excluding them from the M class. Hence the name "pseudo-M" was used, and the P designation was born. The class had been introduced in 1981 as a previously unrecognized class X (10) and for a time was also referred to as the "dark M", or DM, class (11). The designation PM, for pseudo-M, also leaked into the literature (12) causing a great deal of confusion regarding the designation for this class.

Broad-filter IR observations in 1980-82 of several asteroids previously classified as R suggested that a few members of this class differed radically from the rest in their IR spectra, and they became the new class A (13), defined primarily in terms of JHK colors, but also in terms of the U-V color and geometric albedo.

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The taxonomic system in current common use (14) is based on a cluster analysis of the final 8-color survey results. In this system, three unique asteroids are assigned to single-member classes: V (4 Vesta), Q (1862 Apollo), and R (now only 349 Dembowska, the rest of the old Rs being divided between S and A). Another sparsely populated class with colors falling in the gap between S and D, is tentatively identified and given the designation T. The old C class is split into four subclasses (C, B, G, and F) on the basis of albedo and spectral variations at UV and blue wavelengths. Most other traditional classes are preserved in a regularized form, with classes defined in a parameter space based only on 8-color and albedo data. The old U ("unclassifiable in this system") class, which actually contained some of the best-observed and best-understood asteroids (e.g. Vesta) is abolished. Objects for which the published data are apparently inconsistent are now listed as "I" objects.

In parallel with the systems described above, there have been several systems which lie outside the main line of evolution. Most of these were based on the 24-color spectral observations and gave less weight to albedo, and more to the probable mineralogical and meteoritical implications of the spectra (15,16,17). Although the class designations in these systems have no direct descendants today, the groupings and the concepts behind them have clearly influenced later versions of the "standard" system.

A recent elaboration of the "standard" taxonomy is the introduction of three "superclasses" which are based on a classification of the meteoritical interpretations of the spectra, rather than the raw data itself (18). Tholen's 14 classes are gathered into "igneous" (classes V, R, S, A, M, E), "metamorphic" (classes G, B, F, possibly T), and "primitive" (classes C, P, D) superclasses. Members of the same superclass adjoin each other both in 8-color parameter space and in orbital radius.

Historical experience suggests that more changes lie ahead before asteroid classification settles into rigidity. For instance, the members of the Eos asteroid family fall between the C and S classes in many observed parameters and traditionally have been divided between them, yet are mostly classified S in the current version of the standard system. Similarly, some meteorite classes have never fitted comfortably into any version of this system. The superclasses forshadow a future struggle between "splitters" and "lumpers" similar to that in biology.

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