A catalogue of unidentified objects

from David J. Thompson

THE sky seen with a gamma-ray telescope offers a unique view of high-energy astrophysical processes. This uniqueness is emphasized by the second COS B catalogue of high-energy gamma-ray sources (Swanenburg *et al. Astrophys. J. Lett.* **243**; L69, 1981) which documents the remarkable lack of obvious correlation between most of the gamma-ray sources and previously known astronomical objects.

The high-energy gamma-ray telescope aboard ESA's COS B satellite has been in operation for nearly six years and data used in compiling the second COS B catalogue span more than three years. The 25 sources of gamma rays with energies above 100 MeV which make up the catalogue may be either stellar or extended sources (with diameters up to 2°). Although the COS B survey does not cover the entire sky, it does include the full galactic plane, along which most of the sources are clustered. There is also a concentration towards the inner part of the Galaxy. In addition to the simple observation that these sources are galactic, their spatial distribution suggests that they lie within 2 to 7 kiloparseconds of the Solar System and, hence, are radiating on the order of 10^{36} erg s^{-1} in the form of high-energy gamma rays.

Despite efforts by a number of investigators, only four of the 25 sources have firm identifications. The Crab and Vela pulsars are recognizable by their time signatures, having the same periods as the radio pulsars. The quasar 3C273 and the interstellar cloud complex near the star ρ Ophiuchus are identified by positional coincidence, which is meaningful only for these high-latitude sources. An extended source, not appearing in the catalogue, has also been identified by COS B with the molecular clouds in Orion (Caraveo *et al. Astr. Astrophys.* **91**; L3, 1980). The remaining 21 members of the catalogue are distinguished by their lack of counterparts at other wavelengths. In particular, the gamma-ray luminosities of these sources are at least an order of magnitude greater than their X-ray luminosities and several orders of magnitude greater than their radio luminosities. This preferential production of gamma rays indicates an unusual astrophysical setting, dominated by large energy transfers. The fact that the identified gamma-ray sources are not all of the same type suggests that the unidentified sources may themselves not be a homogeneous group. The variety of energy spectra seen for the sources in the COS B catalogue is a further indication that two or more classes of gamma-ray source may emerge from future studies. The intriguing possibility is that at least some of these presently unidentified sources may turn out to be a totally new class of galactic object.

Further results can be expected from COS B, particularly in the area of time variability studies, but positive identification of these mysterious sources depends on future observations. The Soviet–French GAMMA-I satellite (to be launched in the next two years) should give improved position information for some of these. The instruments selected for the Gamma Ray Observatory (now scheduled for launch in the latter part of the 1980s) have the broad energy range, good angular resolution and high sensitivity to provide the next breakthrough in gamma-ray source studies. The importance of the COS B catalogue is that it establishes a sizeable number of gamma-ray sources with astrophysically unique properties.

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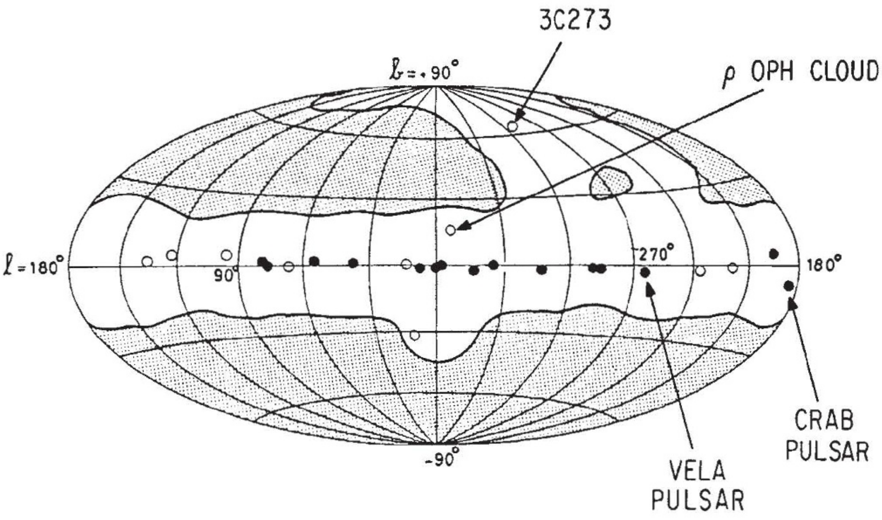

The second COS B catalogue of high-energy gamma-ray sources, shown in galactic coordinates. Observations covered the unshaded region. Filled circles denote sources with measured fluxes $\geq 1.3 \times 10^{-6}$ photons (>100 MeV) cm^{-2} s^{-1}, while open circles denote sources below this threshold (from Swanenburg *et al.* 1981).

convective systems, particularly those associated with magmatic fluids within cracks, are likely to be characterized by a Soret type of isotopic fractionation (as used to produce enriched uranium) that could drastically modify the ratios of even relatively stable, immobile isotopes. The lack of evidence for significant magma chambers beneath the Atlantic and Indian Ocean ridges certainly indicates that the fractionation of the mantle melt to form the oceanic crust probably operated predominantly within tensional cracks in the lithosphere, rather than in a clearly defined magma chamber. The magma chambers thought to have been identified along the East Pacific Rise could, in fact, be areas of the mantle with intensive fractures filled with magmatic fluid, rather than the conventional concept of a large volume of magmatic liquid. Even if magma chambers do exist in such situations, Rice's model could mean that there is much more isotopic fractionation of mantle materials than has generally been recognized. Thus mantle homogeneities postulated on the basis of variation in elements and their isotopes from mid-oceanic ridges to off-centred volcanoes could merely indicate slight differences in the Soret fractionation system in the different areas. Much of the evidence for or against mantle sources for many magmas could similarly be at least gross oversimplifications.

The implications of Rice's model are far-reaching. His paper highlights our ignorance of the fractionation processes in magma chambers, and demonstrates the inadequacy of widely accepted, but incorrect mechanisms for fractionation. It could also mean that we are only just beginning to understand the ways in which igneous rocks are formed and that all previous geochemical interpretations must be re-evaluated. □

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