Chemically challenging elements.

At the various thick-target, ISOL facilities radioactive ion-beams have been developed for about 70 out of the 92 naturally occurring elements. This leaves 22 elements for which target and ion-source technique that would give beams worth accelerating have for chemical reasons proven to be difficult to develop. They belong to the transition elements found in the groups 5B to 7B and 8 of the periodical system. Due to their refractory nature they are often used as target element and construction materials in ISOL targets and ion-sources.
The elements boron, sulfur, silicon and phosphorus belong to the class of elements which are refractory or form predominantly refractory compounds with the usual target and ion-source metals or impurities present in them. Methods for their efficient release and transfer into an ion source remain still to be developed.
There is no lack of ideas on how to develop these beams in connection with thick targets irradiated by high energy beams. By suitable selection of target and ion source materials or by chemical-evaporation technique it seems to be technically possible for a number of them. The very limited resources spent on Nb, Zr, Hf, Ta and W show that beams can successfully be made by addition of CF_4 to the target (Sa84).
Much larger development efforts have been spent on re-acceleration of projectile or target fragments produced in low energy reactions on thin targets. In fact several groups have produced interesting beams of the transition elements by means of the IGISOL technique (De97) in which the recoiling fragments are thermalized and reduced to the 1+ ionized stage in He gas. Until now the beams have been of relative low intensity (up to 7E3 ions/s). The achieved overall efficiencies of 0.03-10% are not affected by decay losses but produce beams of poor emittance still dependent on the chemical properties of the elements (Ra89).
Beams of chemically challenged elements can be developed but requires a dedicated research effort of several man-years like that of the development of the ^{13}N beam at Louvain-la-Neuve (Da90) where nitrogen a few years ago belonged to that class.

Sa84, J. Sauvage et al. Proc. TRIUMF-ISOL Workshop Mount Gabriel, Quibec (J. Crawford and J. M. ‘D,Auria, eds.) Triumf ReportTRI-84-1 (1984) p. 161
Da90, D. Darquennes et al. Nucl. Instrum. Methods B.47 (1990) 311.