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Distinguishing Modern from Relict Weathering Profiles

It is often difficult to establish from geological criteria whether a weathering profile formed in the recent past or whether it is relict from a previous weathering regime. The times at which active weathering of extensive terrains in Australia, Africa and south-eastern United States occurred, for example, have not been determined. Geomorphic and other field relations have commonly been used to time periods of major weathering, and, recently, potassium-argon measurements on fresh basaltic flow rocks associated with weathered rock have been used in an attempt to bracket times of weathering (see ref. 1, for example).

In favourable conditions, weathering can change rubidium and strontium concentrations of rock in such a way as to produce weathered material that can be dated by the Rb-Sr method. Strontium is significantly and progressively removed from rocks undergoing moderate weathering, whereas rubidium is not removed appreciably until more advanced stages are reached. A wide range in the ratio of rubidium to strontium is thereby produced in the weathered profile, and zones with this wide range of Rb/Sr ratios will be datable by Rb-Sr isochron techniques provided, first, that the weathering process leads to a material that initially has a uniform strontium isotope composition, and, second, that subtractions (or additions) of rubidium and strontium effectively cease at the end of a relatively discrete period of weathering.

The first of the two conditions is probably satisfied in rocks with uniform strontium isotope compositions at the time of weathering—for example, basaltic rocks, or very young, more silicic rocks such as granite and rhyolite. The same may also be true of older granitic rocks, provided that they are initially isotopically uniform on the scale of the sampled profile.

Uncertainties arise in the case of older rocks, and particularly more silicic, rocks because "fractionation" or mineralogically selective weathering can occur. In the unweathered rock, radiogenic strontium (^{87}mSr) will reside chiefly in potassic minerals, which are usually more stable during weathering,

rather than in calcic minerals, which contain less radiogenic (common) strontium. In the initial stages of weathering the phases may not weather at the same rate; for example, calcic plagioclase, perhaps containing most of the common strontium, alters more rapidly than potassium feldspar, and the content of ^{87}mSr (and the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio) is thereby increased in the weathered residue. With more extensive weathering potassic phases will alter, and the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the residue may decrease. To achieve initial isotopic uniformity in a profile formed on older granitic rocks, it is probably necessary for all primary, strontium-bearing phases to be completely weathered. This further condition for older granitic rocks may be satisfied in the A and B horizons of mature soil profiles, but not in the C horizon.

On the basis of available data we cannot predict whether completely weathered products will show a net increase or decrease in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio, relative to fresh rock. Nonetheless, uniform weathering of an isotopically uniform rock should yield an isotopically uniform product. The prospect of determining the time of weathering of some relict profiles thus seems good.

The second condition cannot be as easily evaluated. Profiles that formed long ago but are still undergoing active weathering obviously do not meet this requirement. But many weathered zones in the stratigraphic record apparently formed during a relatively short period of time and may have remained essentially closed systems since their formation.

As an example, a weathered dolerite dike from North Carolina has $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of 0.7055 and 0.7138 for whole samples of fresh and weathered rock². If the above criteria are fulfilled the two values yield an apparently reasonable elapsed time of 25 m.y. since effective weathering ceased.

Rb/Sr and $^{87}\text{Sr}/^{86}\text{Sr}$ systematics may still provide a qualitative test of the age of a weathered profile even if the conditions described are not met. Very ancient profiles—even those undergoing active weathering at present and therefore not strictly datable—should show a positive, though possibly non-linear, correlation between Rb/Sr and $^{87}\text{Sr}/^{86}\text{Sr}$. Recently and rapidly formed profiles should have uniform $^{87}\text{Sr}/^{86}\text{Sr}$ throughout.

At best, "ages" obtained of relict profiles by regression of scattered data provide a general idea of the antiquity of the profile, together with a crude index of time constraints. More detailed information may be difficult to obtain. There are many situations, however, in which the method may prove valuable for geomorphologists and soil scientists.

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Effects of Hydrogen Absorption in Palladium and Palladium-24% Silver Foils

THE capacity of palladium and some of its alloys to absorb hydrogen and to allow its diffusion is well known¹, but palladium itself is rarely used as a hydrogen diffusion mem-