IN SITU GEOCHRONOLOGY OF PLANETARY SURFACES: APPLICATION OF THE RUBIDIUM-STRONTIUM ISOTOPE SYSTEM. B. W. Stewart 1, G. Cardell2, M. E. Taylor2, R. C. Capo 1 and D. A. Crown1, 1Department of Geology & Planetary Science, University of Pittsburgh, Pittsburgh PA 15260, 2Device Research and Applications Section, MS 302-231, Jet Propulsion Laboratory, Pasadena CA 91109.

Introduction: A primary objective in studies of solar system evolution is to delineate the timing of geologic processes that shape the surfaces of planetary bodies. Remote sensing of planets such as Mars can provide an important relative chronology of major events, but absolute time scales are currently established only via indirect methods such as impact crater densities, and epoch boundary age uncertainties can reach as high as 2 Ga in some cases (Fig. 1, modified from Tanaka et al. [1]). Meteorites thought to be of Martian origin indicate an extended geologic history for the planet, with ages ranging from ~4.5 Ga to ~0.15 Ga, and the recent suggestion that the oldest of the Martian meteorites contains fossil evidence of life [2] has spurred a renewed interest in the evolution of Mars. The current NASA program of rover-based in situ surface sensors combined with sample return has the potential to greatly enhance our understanding of Mars.

In Situ Requirements: An instrument deployable on Mars or other planetary bodies must meet severe size, mass, and energy constraints, and it must be capable of long-term operation in extreme environments. Moreover, it must have the ability to measure ages that could range from a few millions to billions of years, and should be able to carry out multiple measurements on the same rock unit. Ideally, the integrated instrument would be compatible with planned sampling strategies (e.g., chipping or coring of exposed rocks).

Use of Rb-Sr System: The rubidium-strontium system is a strong candidate for in situ geochronology on the surface of Mars and other rocky planetary bodies. The basis of the Rb-Sr system is the decay of $^{87}\text{Rb}$ to $^{87}\text{Sr}$ by $\beta$ emission (half-life = 48.8 Ga). An age is obtained by measuring the $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{87}\text{Rb}/^{86}\text{Sr}$ ratios of two or more rocks or minerals (generally igneous) thought to be thermally and isotopically equilibrated at time zero (i.e., during crystallization). We focus on this geochronologic system for the following reasons: (1) The Rb-Sr system is ideal for the age range measured for SNC meteorites (thought to represent rocks ejected from the surface of Mars) and has been used successfully on a wide range of extraterrestrial materials, including SNC meteorites; (2) Sr and Rb are present in the major rock-forming minerals at concentrations equal to or exceeding those of the other parent-daughter elements; (3) there are few isobaric interferences (interferences from isotopes of other elements with the same integral masses) in the Rb-Sr mass range; (4) the necessary measurements can be made simultaneously; and (5) resonance ionization potentials of Rb and Sr are relatively low (especially compared to U-Th-Pb and Ar).

Required measurement precision. The primary challenge is to achieve the required precision and accuracy in measuring $^{87}\text{Sr}/^{86}\text{Sr}$ and Rb/Sr ratios. Figure 2 shows the measurement uncertainty required for age uncertainties of 0.5 Ga or less. The calculations are for a two-point isochron; addition of more points could reduce the calculated age uncertainty. As indicated, ages good to ±0.5 Ga or better could be obtained with ratio measurements far less precise than those achievable by terrestrial instruments.

Instrument Design Concept: An in situ Rb-Sr geochronology instrument must be capable of measuring isotope concentrations in multiple mineral crystals from a single rock. Such an instrument would use advanced laser and miniature mass analysis technology to implement the sample preparation, ionization and mass analysis in three closely integrated steps involving laser ablation, resonance ionization, and sector mass spectrometry. These stages currently exist or are under development at the Jet Propulsion Laboratory.