contour information, or to plot only the contour information, or to plot only the spot-heights. Further, it would be possible to extract only the major contours, scale them and plot them in a small scale map with reduced contour interval.

In addition to providing purely graphical features, the interactive editing program provides limited computational features. For example, it permits distances to be scaled-off the drawing and accumulated. When used in conjunction with stream digitising, the facility permits lengths of roads etc. to be scaled directly from maps. Similarly, the program provides a mechanism for calculating arbitrary areas which, when used with the digitiser, provides a convenient planimetric facility.

The interactive editing program is easily incorporated into existing plotter-based graphics systems. Minor modifications to existing programs enable the creation of plot files that are compatible with the editing program. However, if the full benefit of features such as layers is to be achieved, more extensive modifications of existing programs may be necessary.

In summary, the paper describes an interactive graphical editing program that can run on most computers and can eliminate the time-consuming process of manually editing computer generated plots.

LOOKING DEEPER – CHANGING TACTICS FOR URANIUM EXPLORATION

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Uranium exploration is the US, Canada and Ausralia is undergoing a fundamental change. Shallow deposits with surface expression detectable by airborne or ground radiometrics are becoming more difficult to find. Yet it is in these areas where exploration has been most successful in the past few years becuase of subcropping deposits which still retain enormous potential for future discoveries. Geophysical methods such as aeromagnetio EM and magnetometer surveys, coupled with geological interpretations of known deposits, have proved very successful, for example in the Athabasca Basin in Northern Saaskatchewan, where many potential mineralized zones have been located at depths of 150 m or more. However drilling all the possible anomalies has proved an expensive strategy with a low success rate, although at least one deposit (West Bear) has been located in this way (Armstrong and Brewster, 1979).

There is now a need for techniques that can rapidly, and with confidence, pinpoint uraniferous anomalies from the surface. The methods most likely to fulfil this need are those based on the mobility of uranium and its decay products. A summary of the decay series of uranium and the potential of the different isotopes for use in exploration is given in Table 1. Uranium, radium and radon are the most mobile elements, either through their solubility and transport in waters of different compositions or by gaseous diffusion. Helium-4 is produced as a result of alpha decays in the decay of uranium and can also be used as a uranium indicator.

Radon detection is probably the best known method in use for locating buried uranium. It has had a chequered career but the problems associated with direct determinations of radon in soil gas, such as diurnal variations and effects due to weather changes, have been overcome by the use of methods involving long-time integration of the radon measurements. Two systems commercially available use alpha registration films (Gingrich and Fisher, 1976) or silicon surface-barrier detectors (Warren, 1977) to detect the alpha emission of radon decay. Both detectors are placed in the ground above a suspected deposit for periods up to 30 days, but whereas the silicon detector results can be obtained immediately after the waiting period, the films must be processed at the suppliers' laboratory before any results are available. However, if a large area were to be surveyed, the cost of the individual silicon detectors would prohibitive even though they could be reused in later surveys.

Another approach to radon detection is to use ^{210}Pb or ^{206}Pb measurements of near-surface samples as a natural integrator of radon flux. In this case the field cost reduces to that of sample collection. Such methods are at the research and development stage. However there are indications that measurements of $^{206}Pb/^{207}Pb$ or ^{204}Pb ratios could become as straightforward as atomic absorption determinations for trace-elements. At present such ratios are determined by mass-spectrometric measurements. The ^{210}Pb method, which gives a 100 year integration of radon flux, requires chemical extraction and alpha-spectrometry which may make it too expensive apply to field surveys using current methods.

Another technique being investigated as a means of locating deeply-buried uranium deposits involves measurements of helium-4; The decay of one ^{238}U produces one ^{222}Rn atom but eight helium atoms, an amount of 0.115 cm^3 He per tonne ^{238}U per year. Being light and inert, helium has a great tendency to escape into fissures thus allowing migration away from the site of its formation. Field mass spectrometers have been developed to measure helium in soil gas, and also the ration $^4He/^{36}Ar$ (Reimer, 1977) from which corrections can be made for the effect of variations in atmospheric pressure and temperature on the background helium level. Published results of helium surveys parallel the experience obtained with radon measurements. Some buried deposits show He haloes, some do not. However the helium and radon measurements should be considered complementary. ^{222}Rn with a mean half-life of 5.5. days, must move rapidly to give detectable concentrations, whereas helium must accumulate to be recognisable above the general background level of 5 ppm. Hence helium cannot be expected to be as useful as ^{222}Rn in areas where rapid gas movement is possible although where relatively impervious geological structures overlie the suspected deposit, helium contents of soil gas might be the preferred method.

The major problem concerning the application of both radon and helium determinations to the location of uranium deposits is the lack of knowledge on how these, and other uranium decay products, migrate below the surface. The movement of radon is a matter of some controversy; one

TABLE 1. Products of uranium decay with potential as uranium ore indicators

Isotope	Half life	Comments
^{238}U	4.5×10^9 y	Mobile in oxidizing groundwaters
^{234}U	2.5×10^5 y	Increased concentrations in water resulting from α—recoil
^{230}Th	8.0×10^4 y	Least mobile element, indicative of original U location
^{226}Ra	1620 y	Mobile in deep groundwaters, less so in surface
^{222}Rn	3.8d	Inert gas; diffusion distance limited by short half-life
^{214}Pb, ^{214}Bi	~30 m	95% gamma emission of U ores from these isotopes
^{210}Pb	20 y	Gives 100 y integration of radon flux
^{206}Pb	stable	Long time scale integrator of radon flux
^{4}He	stable	Helium produced by alpha decay. Inert, light gas

school of thought maintaining that radon is capable of diffusing in detectable quantities over hundreds of metres. Some impressive results have been published to substantiate these claims from surveys made using the track-etch method (Greigrich and Fisher, 1976). Other studies on surface radon emanation (Gableman, 1977) have found examples of massive spurts of gas which cannot be correlated with the emanation potential of the soil and were interpreted as irregular injections from greater depths. A model of subterrestial fluid convection has also been proposed to account for spurts of radon (Mongro-Campero and Fleischer, 1977). On the other hand geochemical evidence suggests that radon diffusion in dry rocks is small and, if radon is carried by ground-water movement, then those waters will carry the longer-lived ^{226}Ra or ^{238}U as well. Deposition of ^{226}Ra and ^{238}U closer to the surface will then give rise to the surface radon anomalies. The possibility of such movements suggests that geochemical analyses for leachable uranium of ^{226}Ra should also be made of samples taken from beneath the immediate soil horizon.

Thus much remains to be learnt about radon and helium sources and migration below the gound. However, with the increasing number of techniques being proposed and evaluated for their measurement, and the increasingly detailed approach to those evaluations, the relative merits of the methods and their relevance in uranium exploration will become clear. With the present momentum of exploration need, this should occur in the near future.

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PRACTICAL GAMMA SCINTILLOMETRY TOTAL COUNT VERSUS SPECTROMETRY

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The purpose of this paper is to illustrate the relative sensitivities of total count and multichannel spectrometry in uranium exploration.

The spectra of Uranium and Thorium are examined and a comparison made between logarithmic and linear plotting. This emphasises the relatively small number of counts recorded in the 1.76 MeV "uranium" peak and 2.62 "thorium" peak compared with total count. The preponderance of Bismuth 214 peaks in the spectrum is discussed and the lack of any outstanding peaks of other daughter products. Reference is made to work carried out by Mero on the use of lower energy emissions from other daughter products with indication of uranium assaying and determination of equilibrium. The use of simultaneous total count, gamma and beta from prepared samples in uranium assaying is described following work of Eicoltz and Daly & Urquart. This method also indicates the state of equilibrium. The energy spectrum of Thorium is compared with the Uranium Spectrum and the dissimilarities discussed.

The efficienty of sodium iodide as a gamma detector is examined and curves of absorption efficiency have been plott-