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## INTRODUCTION

The resurgence of interest in partial extractions has been such that there have been claims that they are now an essential part of modern day exploration geochemistry. This trend is set to continue as we learn more about the underlying factors controlling element speciation and dispersion, and if we push it to its logical conclusion we may well reach a point where the question will be asked 'Who needs total analyses?' The following three case histories give examples where a total analysis, in combination with a partial extraction, can be either helpful (Case History 1) or essential (Case Histories 2 and 3).

### **CASE HISTORY 1: Kenhardt Block, north-western Cape Province, South Africa**

*The Problem:* The Kenhardt Block, approximately 50 km south-west of Kantiempan, is on or very close to the late Cretaceous African erosion surface. This is a mature peneplain (Fig 1). The climate is semi-arid, pedogenic calcretes under a thin veneer of soil and wind-blown sand are widespread, and the drainage ways are choked with large amounts of wind-blown sand. During routine base metal exploration in this area problems were encountered in differentiating between metal anomalies derived from silicate sources and those derived from sulphides. The resultant orientation survey was designed to investigate refinements in sampling and analysis which would enhance the signature from sulphides while suppressing that from silicates as much as possible. Orientation surveys can be exhausting - in this case a total of 57 stream sediment samples were sieved and analysed by a variety of methods to yield a final total of approximately 20,000 element determinations (Garnett, 1983). Only a small proportion of the total data set will be summarised here.

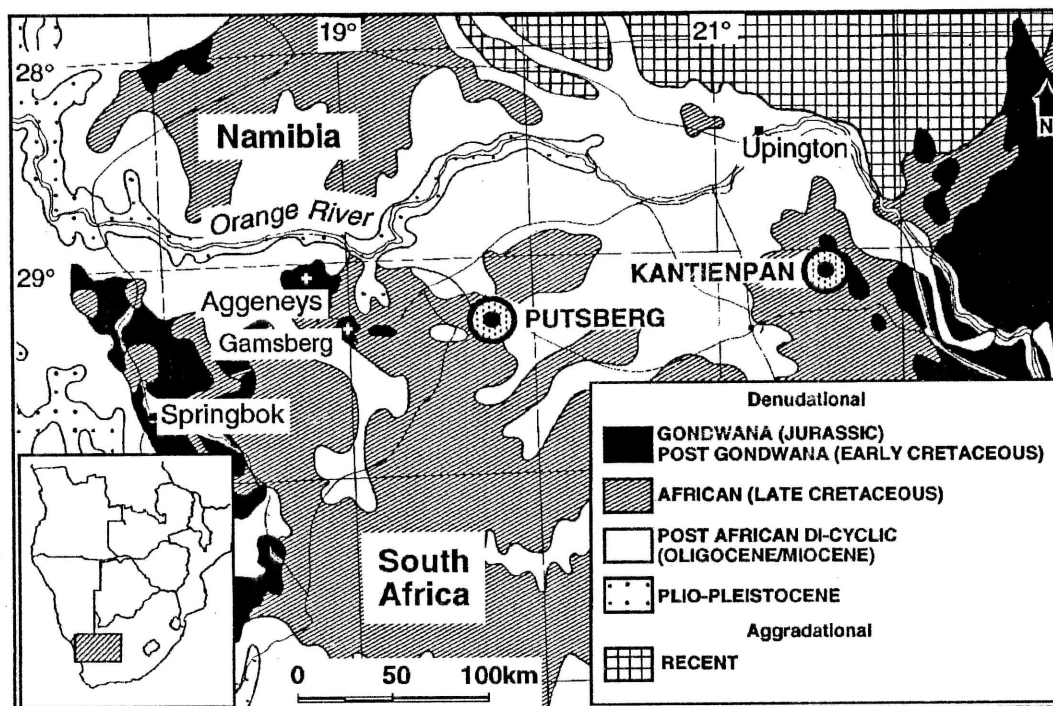


Fig 1. Land surfaces of the north-western Cape Province, South Africa (adapted from Partridge, 1975), showing the regional setting of the Kenhardt Block (50 km south-west of Kantiénpan) and Putsberg prospects described in Case Histories 1 and 2.

*Materials and methods:* Bulk (3 - 4 kg) stream sediment samples were collected from drainage channels in the vicinity of a copper sulphide source on the farm Klein Mottels Rivier and in the vicinity of a silicate source on the farm Lief Dood. Each sample was screened to a range of mesh sizes and each was in turn subjected to a variety of analytical digests. The results described here are for copper determined by atomic absorption spectrophotometry after two different digests of the  $< 75\mu\text{m}$  fraction. The first digest was a hot perchloric - nitric - hydrofluoric (18 : 1: 1) acid attack designed to achieve total or near total dissolution of most sample matrices. The second digest was much weaker, involving use of a cold 0.25% EDTA solution. This was added to the samples, which were then shaken for four minutes and allowed to stand before before reading.

*Results:* Results for the total acid digest, the EDTA leach, and a comparison of the two are shown in Figs 2, 3 and 4 respectively.

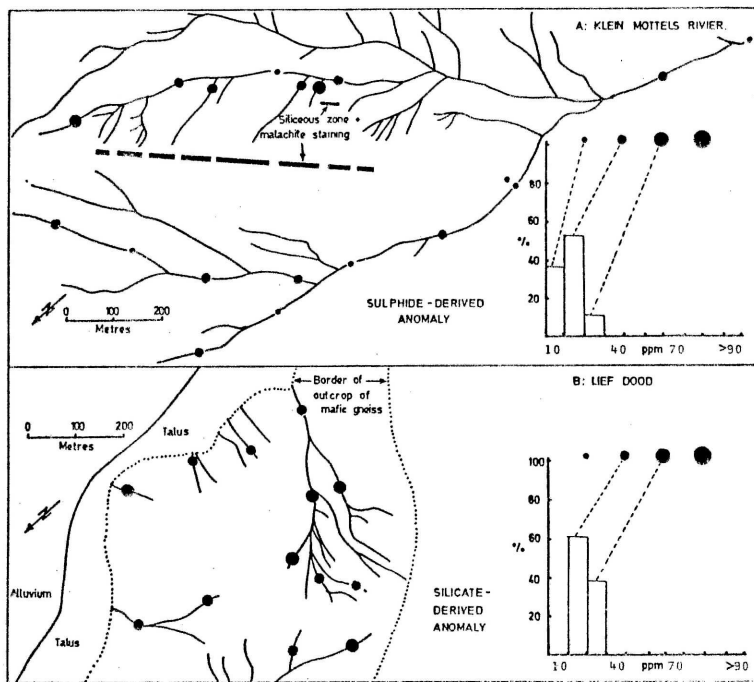


Fig. 2. Copper < 75µm fraction.  
Total digest. The sulphide source is shown above, the silicate source is below.

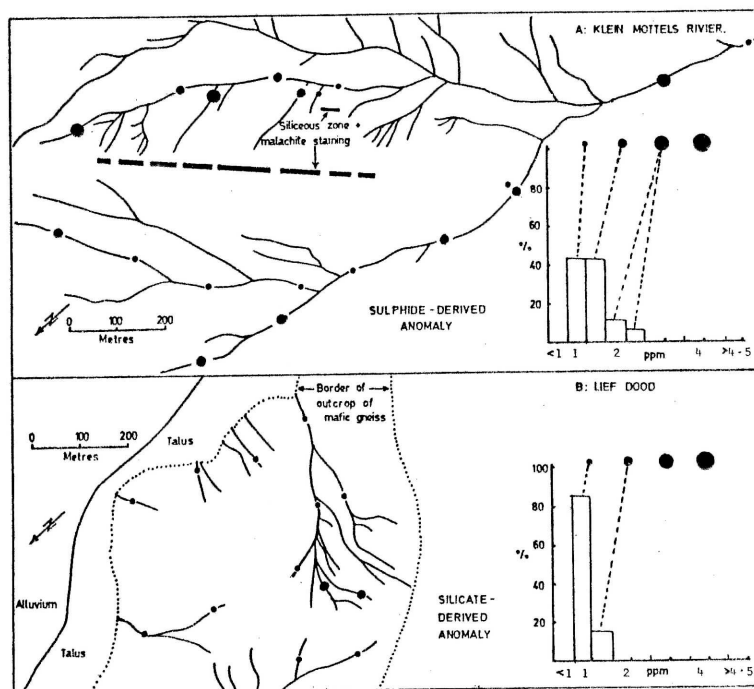


Fig. 3. Copper < 75µm fraction.  
EDTA digest. The sulphide source is shown above, the silicate source is below.

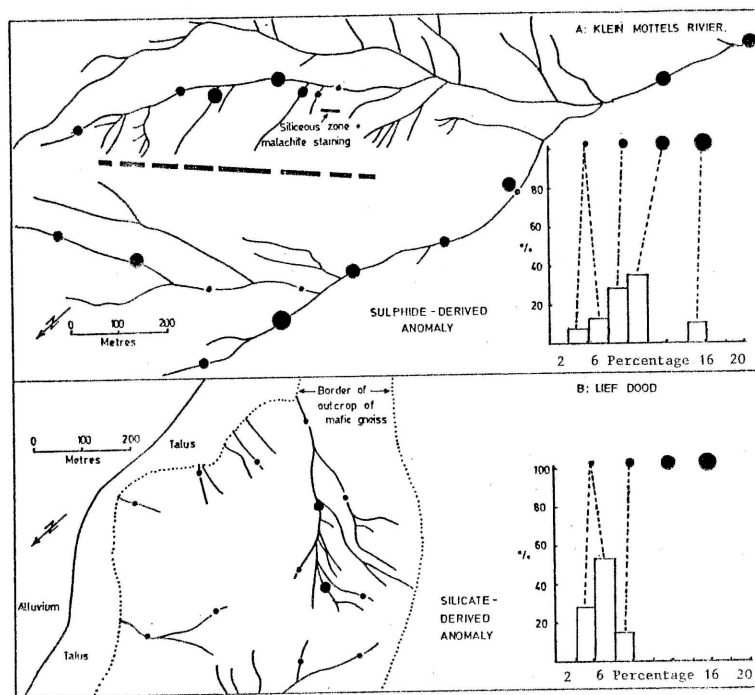


Fig. 4. Copper  $< 75\mu\text{m}$  fraction. EDTA x 100 / Total digest. The sulphide source is shown above, the silicate source is below.

*Discussion and Conclusions:* The total digest (Fig 2) allowed no discrimination between sulphide and silicate sources. Indeed, the silicate source gave somewhat higher and more uniform values. The EDTA leach (Fig 3) gave enhanced values at some sample sites around the sulphide source while the signature from the silicate source was largely suppressed. In this case it could be argued that an EDTA digest alone would have had a reasonable chance of detecting the sulphide source but it is worth noting that the anomalous values detected using EDTA were subdued and lacked continuity. The clearest and most coherent response came when the EDTA values were expressed as a percentage of the total values (Fig 4).

Thus, in this example a total analysis was helpful in achieving maximum discrimination between sulphide and silicate sources.

## **CASE HISTORY 2: Putsberg prospect, north-western Cape Province, South Africa**

*The Problem:* The Putsberg prospect is in a similar setting to the Kenhardt Block described above in that it is on a mature peneplain (Fig 1). The climate is semi-arid and pedogenic calcretes and wind-blown sands are common. The Putsberg copper deposit is covered by 0.5 to 3 metres of calcrete, with incipient calcretisation of bedrock down to 7 metres. Soil geochemical anomalies are so subdued that they were not even recognised during the initial exploration phase and the objective was to identify the sampling and analytical approach which would best enhance the geochemical response of the mineralisation in such a challenging environment.

*Materials and methods:* Both the sand choked drainage ways around the deposit and the calcrete overlying it were sampled and subjected to a range of investigations (Garnett, 1983, 1995). A portion of the work on the calcretes is described here. This was aimed at identifying the location of any remaining ore-related elements that might still be preserved at the top of the calcrete. If this fraction could be isolated then anomalies could be enhanced and therefore recognised with greater confidence.

Examination of the calcretes showed that they often appeared to retain small amounts of residual material derived from bedrock, mixed with and surrounded by introduced material such as calcite, dolomite and amorphous silica. Elimination of as much of the carbonate as possible might therefore be expected to leave a residue enhanced in ore-related elements. Samples collected from the top of the calcrete overlying the mineralisation were pulverised and then leached with 1M ammonium acetate solution, buffered with acetic acid to pH 4.5, as described by Gatehouse, Russell and van Moort (1977). After completion of the leach the leach liquor and the residue were separated by filtration. The leach liquor was analysed while the residue was recovered, weighed and a portion was then analysed following a hot perchloric - nitric - hydrofluoric digest designed to give near total digestion.

*Results:* Results for zinc, together with the profile for the overlying soil, are shown in Fig. 5.

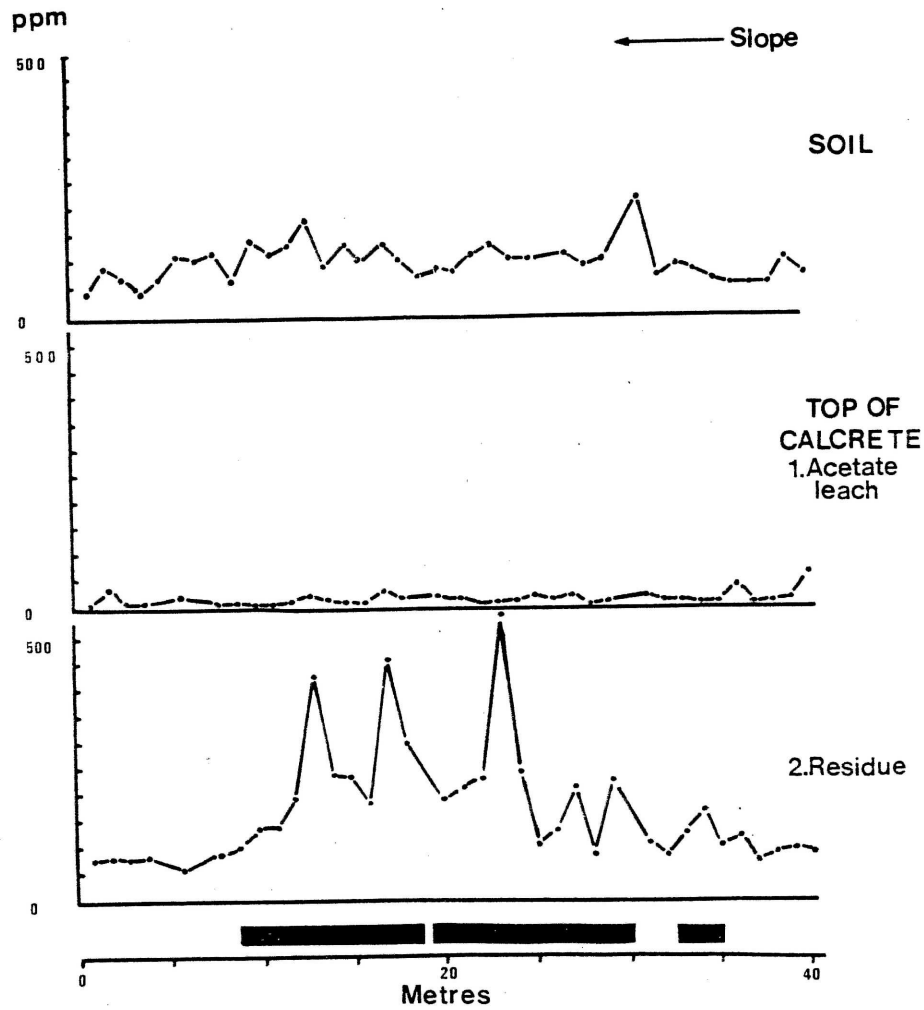


Fig. 5. Putsberg trench. Zinc in an acetate leach of the top of the calcrete compared with total assays for soil and the leach residue. (Adapted from Garnett, 1982). The solid black bars represent the location of mineralisation below the calcrete.

*Discussion and Conclusions:* It is clear from Fig 5 that the residue that remains after an acetate leach is the main host to ore-related elements. Material introduced during calcretisation only serves to dilute the signature of the underlying mineralisation.

In this example a partial leach was useful in eliminating material of no interest while a total analysis was essential in order to define the anomaly.

### CASE HISTORY 3: Soils samples, Papua New Guinea

*The problem:* Even so-called total acid digests may fail to dissolve a range of refractory minerals. Such digests then become partial extractions. However, this can be turned to advantage if an alternative analytical technique which does not rely on sample digests, such as X-ray fluorescence or instrumental neutron activation analysis (INAA), is used to generate total analyses.

*Materials and methods:* Soil samples collected in the vicinity of mafic to ultramafic rocks in Papua New Guinea were analysed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) following a hot acid digest (perchloric - nitric - hydrochloric - hydrofluoric) which was intended to give a near total analysis. The same samples were also analysed by INAA.

*Results:* These are summarised in Fig 7, which shows the extent to which the INAA results for chromium exceeded those obtained by ICP-AES (Garnett and Waldron, 1995).

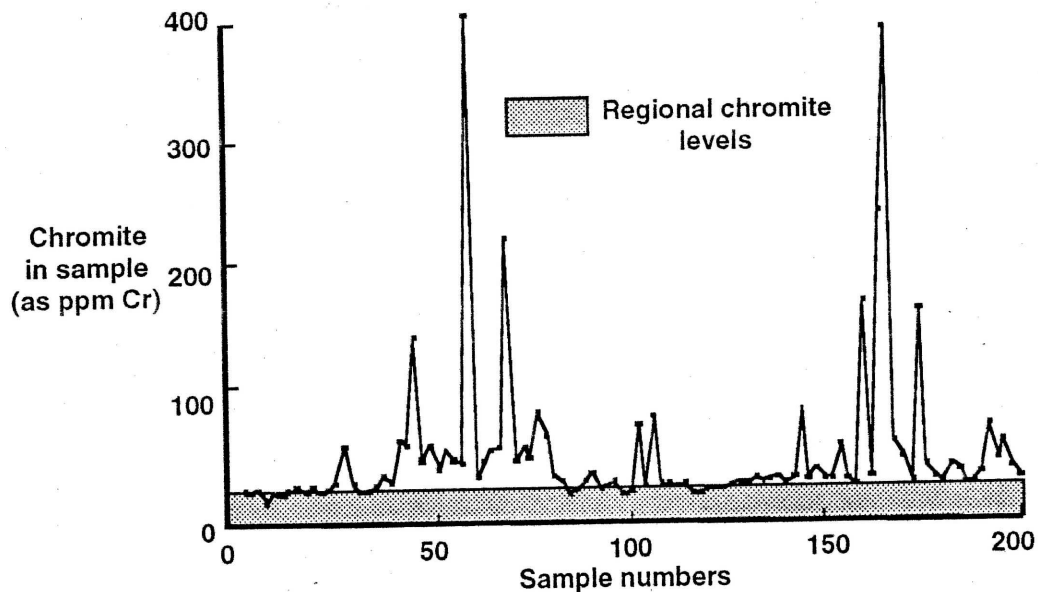


Fig. 7. Estimated chromite contents of soil samples from Papua New Guinea, expressed as ppm chromium in the samples. The plot is derived by plotting the amount by which INAA total chromium values exceeded ICP-AES acid-soluble chromium values for each sample.



*Discussion and Conclusions:* The INAA results were invariably higher than the equivalent ICP-AES values. While this could have been due to analytical bias, it is more likely that the difference was due to incomplete dissolution of chromite by the acid digest. If this was the case then the differences between the two sets of values could be taken as a measure of the amount of chromite in the samples. Such information could be useful in, for example, platinum exploration since there is often a close association between platinum group elements and chromite.

While analytical techniques are used to measure element abundance, a combination of a partial and total analyses can open the way for an educated guess on the possible mineral host(s) of elements detected in the sample. This is information which cannot be acquired by use of a single analysis - in this case history partial and total analyses are of equal importance.

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