Physical Properties of the Elura Prospect, Cobar, NSW

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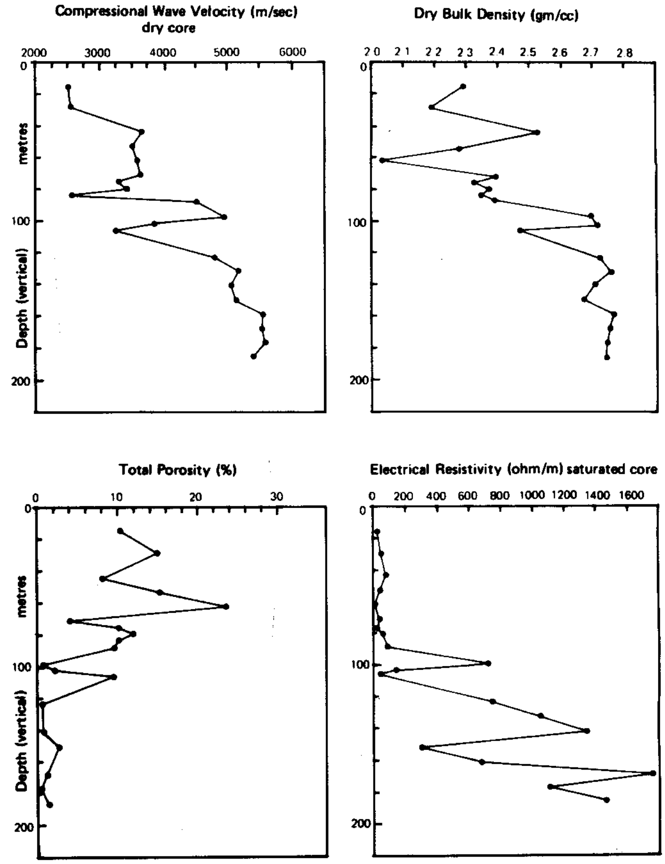
A petrophysical laboratory study was carried out on core samples from the Elura ore body and country rock. The ore, gossan and rock samples came from: the exploratory crosscut off the shaft; DDH holes E25 and E28; and DDH holes E8 and E20A respectively. Careful measurements were made using standard procedures. The properties measured and the results obtained are presented in the Table. A depth plot of some properties is given in the Figure. It should be noted that: the siltstone country rock is intensely weathered to about 90 m; beyond this the siltstone is very slightly weathered to about 150 m depth; the perched (?) water table is at about 80 m; the gossan samples are from the northern (siliceous) subsurface and southern (pyrrhotitic) surface and subsurface; the country rock samples are from the east of the orebody.

In this investigation the cores were dry for the density and velocity tests, but they were vacuum saturated with 0.3 ohmm NaCl solution for the resistivity and induced polarisation tests. The results, except for the gossan resistivities, are considered representative of *in situ* conditions given the low porosities at depth and the low critical water saturation of the "dry" weathered zone where even water saturations as low as 50% do not have a great effect on measured resistivities (less than 100% increase).



ELURA COUNTRY ROCK – DEPTH PROFILES OF LABORATORY MEASURED PROPERTIES
(Base of intense, complete weathering is 90 m approx.)

Laboratory Measurement on each Rock Type: Elura Massive Sulphide Deposit

Physical Property	Weathered Country Rock	Siltstone Country Rock	Gossan	Fresh Ore (Zn-Pb-AgS) Pyritic Ore	Fresh Ore (Zn-Pb-AgS) Pyrrhotitic Ore
Number of samples	10	11	7	10	10
Depth below surface (vertical) in metres	15 to 84	88 to 185	96 to 100	160	160
Resistivity, ohm.m (@ f = 1 Hz & ρ_W = 0.3 Ωm) range: mean ± standard deviation	5 – 95 37 ± 29	42 – 1750 845 ± 552	32 – 124 70 ± 35	0.09 – 0.52 0.25 ± 0.10	0.10 – 0.19 0.125 ± 0.03
Percent Frequency Effect % (@ ρ_W = 0.1 Ωm, f = .1 & 1 Hz) range: mean ± standard deviation	negligible	negligible	negligible	5 – 39 25 ± 11	3 – 23 14.5 ± 7
Chargeability (mV/V @ 800 m sec) range: mean ± standard deviation	negligible	negligible	negligible	61 – 125 82 ± 18	16 – 109 55 ± 27
Acoustic Velocity, V_P, m/s, range: mean ± standard deviation	2,458 – 4,533 3,315 ± 640	3,250 – 5,588 4,917 ± 745	3,412 – 4,768 4,294 ± 619	5,250 – 6,111 5,580 ± 390	
Dry Bulk Density, gm/cc mean ± standard deviation	2.32 ± 0.13	2.70 ± 0.08	3.02 ± 0.54	4.42 ± 0.13	4.42 ± 0.06
Grain Density, gm/cc mean ± standard deviation	2.63 ± 0.08	2.74 ± 0.02	3.77 ± 0.57		
Total (Bulk) Porosity, %, range: *mean ± standard deviation*	3.6 – 23.7 11.7 ± 5.3	0.4 – 9.2 1.69 ± 2.0	15 – 30 20 ± 5	very low	
Effective (Apparent) Porosity, %, range: mean ± standard deviation	3.1 – 20.1 7.1 ± 5.2	0.1 – 1.9 0.3 ± 0.5	4 – 20 11 ± 6	very low	
Magnetic Volume Susceptibility x 10^6 cgs, mean ∓ standard deviation	negligible	negligible	10 ± 10	79 ± 56	4,360 ± 1,080

The results are quite instructive and clearly show the orebody to be dense, magnetic (Po core only) and conductive compared to the country rock, but there is only a moderate induced polarisation effect and no compressional wave velocity contrast. The gossan is relatively dense and porous compared to the intensely weathered zone and more resistive with a higher (ultrasonic) velocity, but the *in situ* effects of low water saturation, vugs and cavernous zones on these properties are difficult to estimate except to say that the resistivity and acoustic contrasts would increase and decrease respectively. In the country rock, density and velocity increase, somewhat erratically, with depth while porosity (quite high in the weathered zone) decreases. Resistivity sharply increases at about 90 m, the base of complete weathering, and this depth marks a change in the other physical properties. Grain densities, obtained by pycnometry, reflect the mineral constituents in the fresh siltstone (micas, chlorite, carbonate), intensely weathered zone (quartz and kaolin) and gossan (limonite).

From the electrical data on weathered zone cores true and apparent formation factors were determined to lie in the ranges 72 to 2000 and 17 to 317 respectively. The porosity dependent formation factor relates the rock resistivity to its saturating water resistivity. However, apparent formation factor cannot be used to calculate porosity in argillaceous rocks, and the true formation factor normally cannot be determined unless there is a lot of auxiliary control. A very approximate relationship between the true formation factor (F_t) and % effective porosity (p) for the weathered zone siltstone is $F_t = 1451 - 260\,p + 19p^2$ $(1 \leqslant p \leqslant 10)$.

The data cited in this note relate to tests on a limited number of samples from part only of the Elura subsurface environment. It is not claimed that the results accurately and definitively depict the physical properties of the important subsurface zones, but it is considered that the results are indicative of the average physical properties and their ranges, contrasts and depth dependence.

NOTES

1. Subsequent to these tests eleven small cores of *siliceous ore* (semi-massive to disseminated sulphide) were obtained from DDH's E28, E31, E33 at depths of 186, 132 and 255 m, in the middle, north and southwest of the orebody respectively. The laboratory measured average resistivity of 34 ohmm was distinctly greater than the massive sulphide resistivities, 0.1 to 0.3 ohmm. The average PFE of 220% was much greater than the massive sulphide IP effects of 15 to 25%. It would seem that the siliceous sheath of the orebody has a relatively high resistivity and strong IP effect. Although its resistivity is greater than the pyritic/pyrrhotitic ore, it is still much less than the unweathered country rock. The average dry bulk density of 3.79 gm/cc (range 3.41-4.21) is less than the massive sulphide density, but still much greater than the country rock. Effective porosities for the siliceous ore were low, averaging 0.04%.
2. *Surface gossan* samples from 50740N/2490E on the southern (pyrrhotitic) gossan were tested after the deep gossan results had been tabulated. Grain and bulk densities, 3.93 and 3.09 gms/cc respectively, were similar to the deeper gossan, as were total and effective porosities, 22 and 20% respectively. A low resistivity, 7 ohmm, and small PFE, 15%, were noted in tests on fully saturated ore. However, *in situ*, the gossan resistivity would be expected to be high because of low water saturation, and the IP effect would become negligible. Ultrasonic velocity measurements indicated a velocity of 4000 m/sec suggesting that massive parts of the gossan body near the surface should have a high velocity compared to the weathered surface layers of the country rock. It was noted that the surface gossan was much softer than the deeper gossan which, despite its porosity, is a fairly tough rock.
3. Laboratory procedures used in this study followed:

Emerson, D. W., *Proc. Aus. I.M.M.* No. 230, 1969
Manger, G. E., *USGS Bull.* No. 1144-E, 1963
Hunt, G. R. et al., *U.S.G.S. Circular* No. 789, 1979.

The study was carried out after the symposium in order to provide additional data.