Base-metal deposits in the Early Proterozoic Glengarry terrane, Western Australia

by G. Le Blanc Smith, F. Pirajno, D. Nelson, and K. Grey

Abstract

The southeastern terrane of the Glengarry Basin contains chert and stromatolitic carbonate units from both the Glengarry and Earaheedy Groups that are unconformably juxtaposed with black carbonaceous argillite along easterly trending faults. Chert breccias and hydraulically fractured laminates occur between stromatolitic units, which are locally silicified. Field observations suggest that the fractured and brecciated horizons were palaeoaquifers, which were contained between relatively impermeable chertified stromatolitic units near the unconformity between the Glengarry and Earaheedy sequences. Pervasive silicification resulted in a gradual build-up of fluid pressure and consequent hydraulic fracturing when this pressure exceeded the lithostatic load. The presence of hydrocarbon residues, local base-metal anomalies, and the silicification and brecciation of specific horizons has implications for the genesis of hydrothermal mineral deposition. Metal ores may have precipitated from the overpressured hydrocarbon-rich brines by processes such as hydrocarbon-gas expulsion during thermal maturation of source rocks. Lead-isotope data indicate a model age of 1.65 Ga for the mineralization.

KEYWORDS: Proterozoic, Glengarry, Earaheedy, base-metal, carbonate, Mississippi Valley, hydrocarbon, stromatolite, breccia, palaeoaquifer, lead-isotope dating.

The Glengarry terrane contains a thick sequence of Early Proterozoic sedimentary and volcanic rocks, largely within the Capricorn Orogen between the Yilgarn and Pilbara Cratons (Fig. 1). The area has been mapped, and a preliminary stratigraphy determined, at a scale of 1:250 000 (Elias and Bunting, 1982; Elias et al., 1982; Gee, 1987). The northwestern margin of the Glengarry terrane is in tectonic contact with the Peak Hill and Border tectonostratigraphic terranes (Pirajno et al., this volume) and is preserved in an easterly trending, terraced rift setting over the Yilgarn Craton to the south and east.

The Glengarry terrane

The Glengarry terrane is characterized by a volcano-sedimentary sequence that is relatively undeformed and has undergone low-grade metamorphism (Fig. 1). Significant differences in depositional facies and stratigraphy exist between the Peak Hill and Glengarry terranes, and these will be discussed elsewhere in the course of the new-initiative mapping program.

* Capitalized names refer to standard map sheets.

The stratigraphy of the Glengarry terrane is being re-examined. It is necessary to establish the stratigraphy of the principal units in order to determine the migration history of metals and hydrocarbons, and their possible subsequent alteration. Two principal stromatolitic chert–dolostone units occur at the base of the Earaheedy Group and the underlying Glengarry Group respectively. Grey (1994a) postulates a depositional age older than 1.8 Ga for the Earaheedy Group based on comparative biostratigraphic studies. In the south of the Glengarry terrane these units are unconformably juxtaposed, and there appear to be interfaces with black argillite along easterly trending extensional faults. This is significant considering that Mississippi Valley-type (MVT) deposits are commonly close to unconformities of regional extent where fluid migration may be enhanced (Callahan, 1967; Sangster, 1988).

Stromatolite occurrences near Crystal Well

A significant number of microbial-laminated and stromatolite-bearing strata occur within the Glengarry sequence (Gee and Grey, 1993; Grey, 1994b). The stromatolite succession is characterized by diagnostic stromatolite taxa, and specimens from new localities are not only consistent with distributions previously recorded, but also suggest that further refinement of the stratigraphic subdivision is feasible. An intercalation of at least four stromatolitic cherty carbonate units separated by thin, hummocky cross-stratified, calcareous silty sandstone (HCS) occurs in the hills

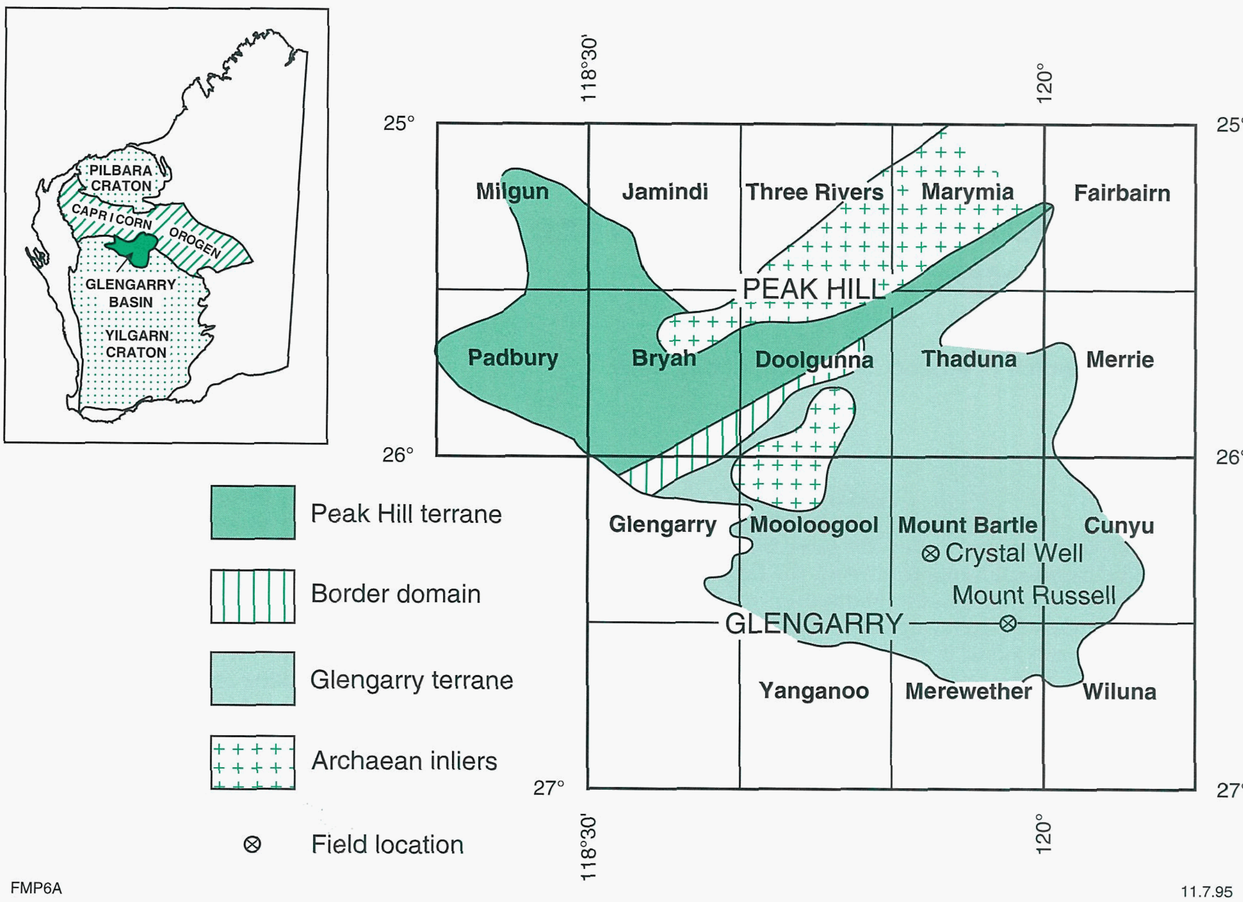

Figure 1. Location map of the area covered by Early Proterozoic Glengarry sequence rocks

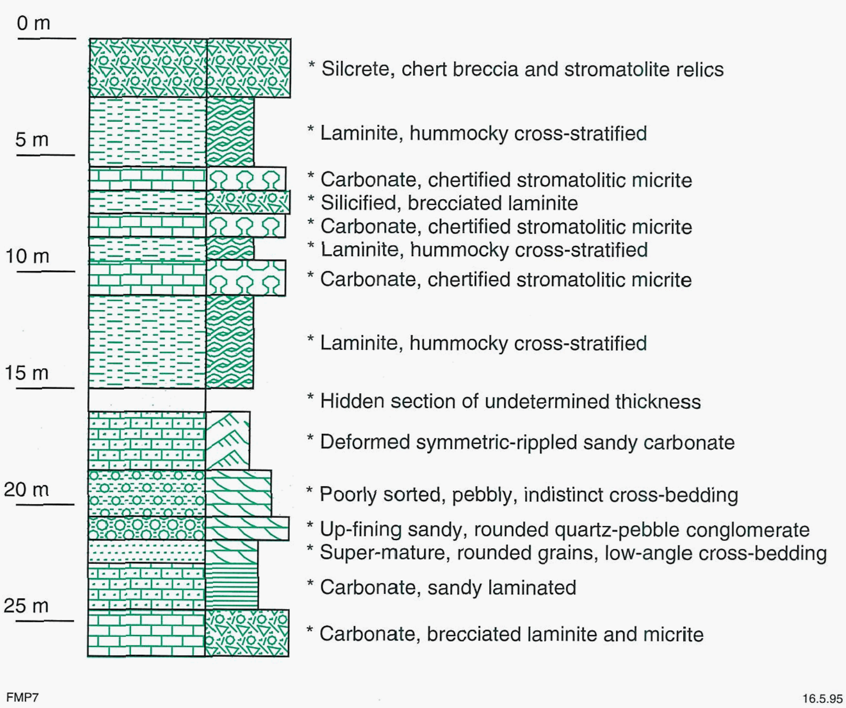

Figure 2. Composite stratigraphic column — Crystal Well area

to the southeast of Crystal Well on Paroo Station (latitude 26°16'37"S, longitude 119°39'02"E); these are underlain by a thin sequence of mature stratified quartz-pebble conglomerate and cross-stratified sandstone, which overlie a carbonate-breccia unit of undetermined thickness. The exposures are limited and weathered, and interpretation of the depositional structures is not conclusive. The siliciclastic units are interpreted as shoreline deposits that prograded onto a carbonate-shelf sequence before being transgressed and reworked by shelf processes. The origin of the underlying carbonate breccia is the subject of current studies. It is possibly a karst surface associated with an unconformity between the Glengarry and Earaheedy Groups, but could be a collapse breccia associated with dissolution of evaporite minerals, or debris associated with carbonate reef structures. The overall sequence indicates broad transgression and deepening of the basinal waters.

Chert breccias

Chert and chert–dolostone breccias and hydraulically fractured laminates occur between stromatolitic dolostone units, which are locally silicified. Breccia fragments have small displacements at some localities, and the original laminate morphology can be visualized due to the 'jigsaw' nature of the breccias. These units are areally extensive, and field observations suggest that the fractured and brecciated horizons were palaeoaquifers, contained between relatively impermeable stromatolitic units. Pervasive silicification resulted in a gradual build-up of fluid pressure and consequent hydraulic fracturing when this pressure exceeded the lithostatic load. An idealised composite stratigraphic column illustrating these features is shown in Figure 2. The silicification and brecciation of specific horizons has implications for the genesis of hydrothermal sulfide deposition.

Mineralization

Black argillite in the Glengarry sequence is locally anomalous in copper (up to 2800 ppm), zinc, and mercury (Drummond, 1984). Recent exploration activity has located a number of anomalies. Some of these are significant, such as the estimated 220 Mt lead-carbonate and -oxide deposit announced by RGC Exploration in 1993. Cored intersections of thick black carbonaceous argillite and chert–carbonate breccia in the southeastern area (Fig. 3) show possible coalified hydrocarbon residues (Drummond, 1984) that were probably sourced from stromatolitic units and black argillite, and subsequently migrated into the carbonate breccia. The formation and migration of petroleum as a consequence of the burial and maturation of organic-rich source rocks are well recorded in the Precambrian (McKirdy and Hahn, 1982), and Proterozoic hydrocarbon accumulations have been reported from Siberia (Meyerhoff, 1980), the McArthur Basin (Jackson et al., 1986), and from the Transvaal Sequence (Roberts et al., 1993). This has implications for the occurrence of MVT and other basin-related base-metal deposits in the Glengarry sedimentary sequence.

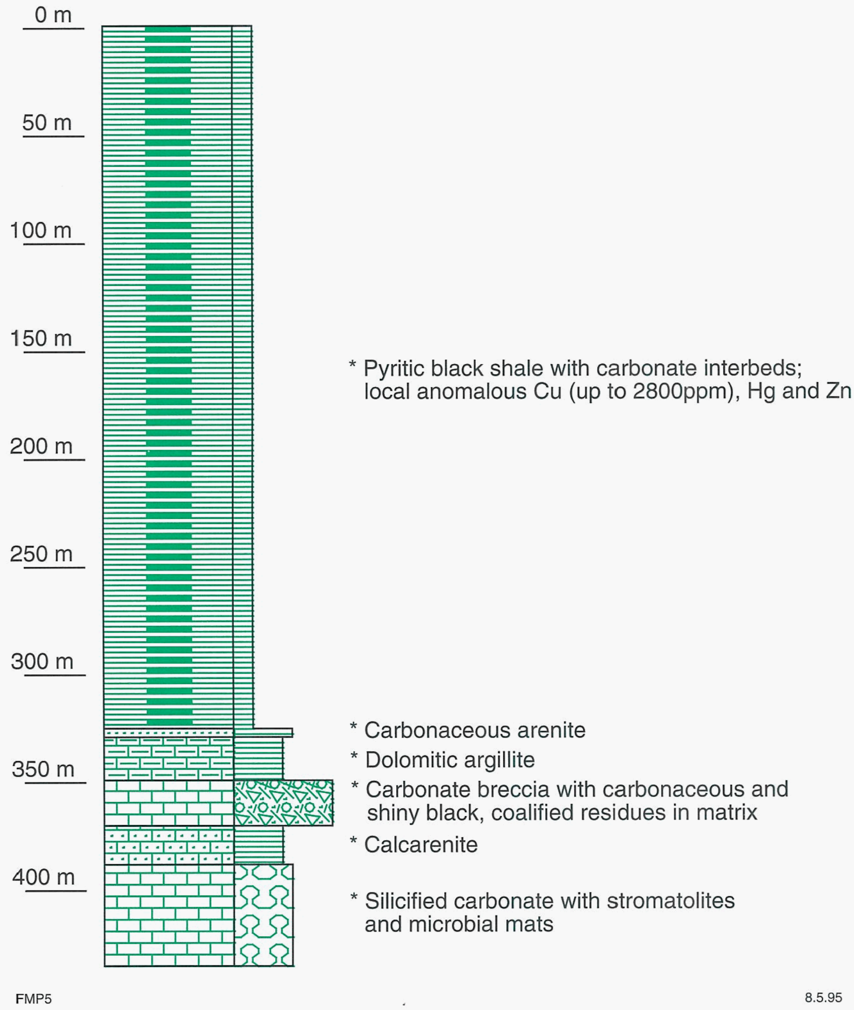

Figure 3. Composite stratigraphic column — Mount Russell area (latitude 26°31'S, longitude 119°51'E)

Coalified hydrocarbon residues in carbonate breccias, possibly similar to those of the Glengarry sequence, are recorded in association with base-metal accumulations from the Transvaal Sequence in South Africa (Wheatley et al., 1986; Roberts et al., 1993), and from the Palaeozoic Lennard Shelf, Canning Basin, northwestern Australia (Eisenlohr et al., 1994). Metal-ore precipitation could have occurred from over-pressured fluids by processes that include the expulsion of hydrocarbon-rich brines, propelled by hydrocarbon gas produced during the thermal maturation of the source rocks. The source of this large amount of lead is unknown; however, it can be speculated that the lead was derived from the feldspars of the feldspathic units in the sedimentary sequence. The derivation of lead from permeable feldspathic horizons has previously been suggested for MVT deposits (Doe and Delevaux, 1972).

Structural and palaeoenvironmental reconstructions using both surface and subsurface mapping techniques could be used to reconstruct and locate the principal routes of hydrocarbon and metal-bearing brine migration, and the loci of the principal depositional facies (including evaporites, carbonate reefs, shelf sandstones, and marginal-slope facies) that have potential for metals accumulation.

Two samples collected by the Geological Survey of Western Australia were analysed and dated using the Pb–Pb model-age method (Cumming and Richards, 1975). Analytical results are given in

Table 1 and the results of the dating are shown in Figure 4. The lead-isotope data indicate a model age of 1.65 Ga.

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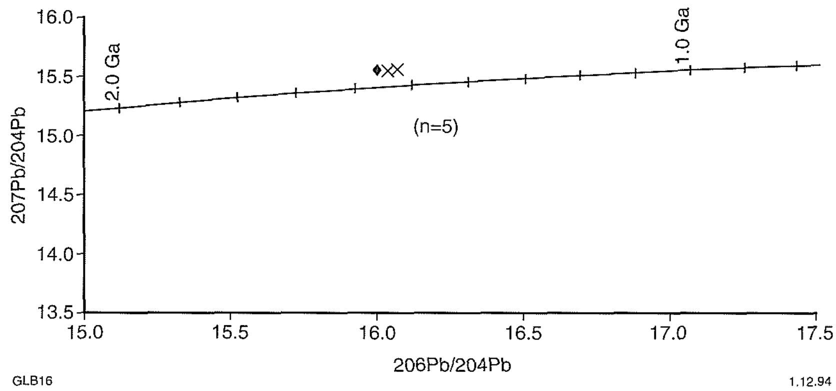

Figure 4. Lead-isotope plot showing the Cumming and Richards (1975) ore lead-isotope evolution curve and the analyses obtained for lead minerals from the Glengarry terrane

Table 1. Selected whole-rock and trace-element analyses of samples 112725 and 112729, which have a Pb–Pb model age of 1.65 Ga (see Fig. 4)

	(a)112725	*112729*
	percent	
Fe_2O_3	2.38	0.43
	parts per million	
Ag	43	12
As	7	<4
Au	<10	<10
Ba	442	115
Bi	<4	<4
Cd	<5	<5
Ce	<6	<6
Cr	60	21
Cu	265	95
Ga	293	297
Ge	4	5
La	19	13
Mn	24	54
Mo	3	<2
Nb	<7	<7
Ni	42	15
Pb	431 300	484 600
Rb	50	46
Sb	<4	<4
Sn	<4	<4
Sr	<2	<2
Ta	<5	<5
Te	<6	<6
Th	<2	<2
U	<2	2
V	62	20
Y	<2	<2
Zn	64	32
Zr	220	206

(a) Geological Survey of Western Australia sample number

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