

6. Gold exploration in the north of Ireland: new targets from the Tellus Projects

GARTH EARLS¹

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Although a local origin of Irish Bronze Age gold artifacts has never been confirmed, the widespread distribution of gold particles in stream gravels suggests a local bedrock origin. Significant bedrock mineralisation was discovered in County Monaghan in the 1950s, and in County Tyrone in the 1980s. The Tellus geochemical surveys have revealed the wide distribution of anomalous concentrations of gold in deep soils and stream sediments throughout the region. In addition to prominent anomalies surrounding the already known bedrock occurrences, clusters of anomalies are found in the Lower Palaeozoic rocks of north County Down and in counties Monaghan and Cavan; in counties Sligo and Donegal; and associated with postulated north–south lineaments in counties Tyrone and Londonderry.

Tellus geophysical data complement the geochemical data by providing information on geological structures, particularly where these are concealed by glacial overburden and peat. A conceptual understanding of mineralisation processes and field experience of mapping prospective rocks are essential for optimising the value of the Tellus information in future exploration.

INTRODUCTION

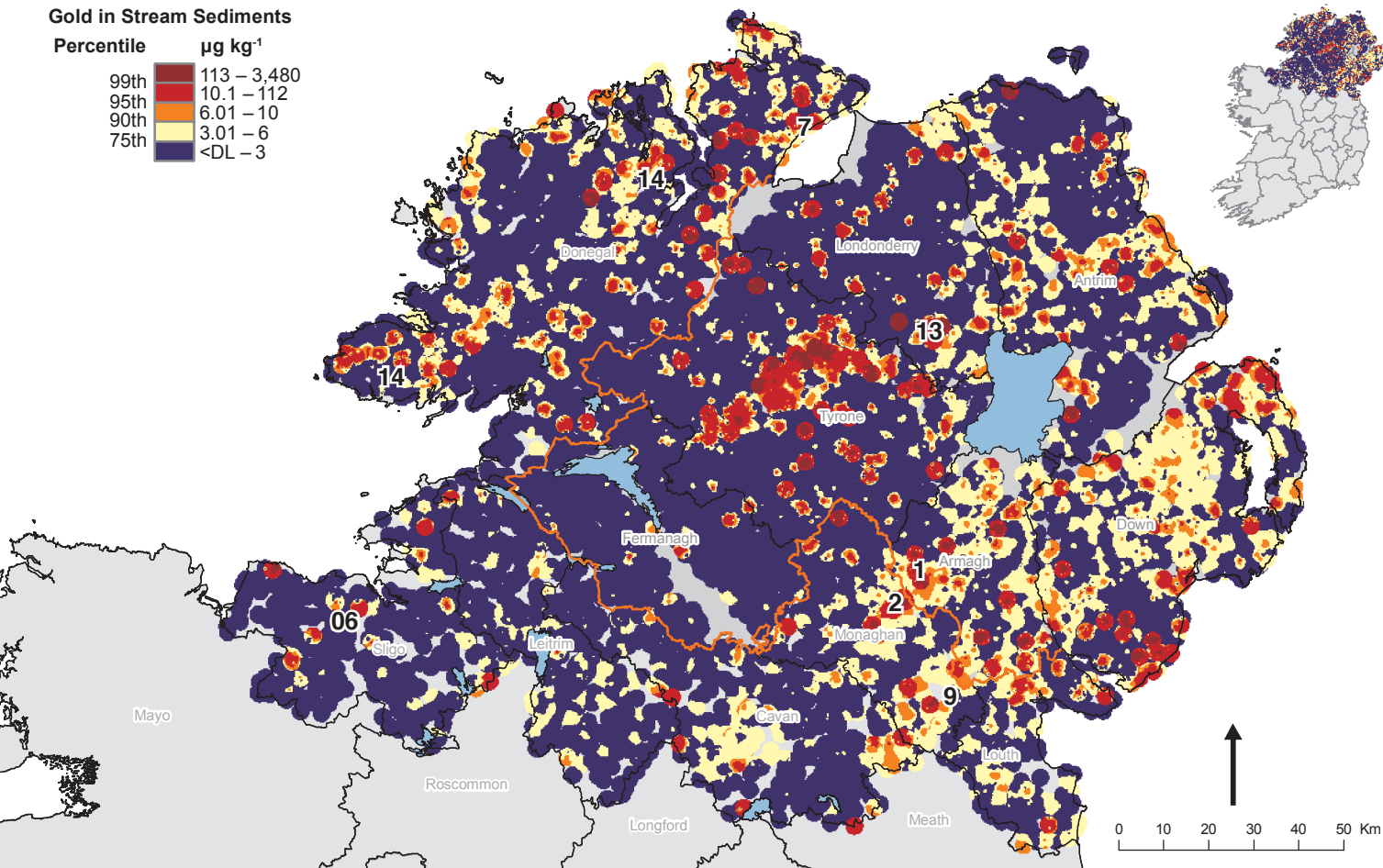
Before Tellus commenced there were about 70 bedrock gold occurrences where grab or channel samples assayed in excess of 1 g/t gold in the north of Ireland (Earls *et al.*, 1996 and references therein). The amount of auriferous float discovered was an order of magnitude greater than the incidences of bedrock gold. The information regarding the distribution of float alone suggests that more bedrock occurrences lie hidden beneath the glacial overburden and Holocene peat. This is reinforced by the data from the Tellus Projects which have defined areas, both geochemically and geophysically, that bear geological similarities to the known deposits and areas of float mineralisation.

The challenge now is to use the Tellus data to reinforce careful mapping and diligent prospecting to discover further bedrock gold occurrences and, it is hoped, new economic

¹ University College Cork.

Gold in Stream Sediments

Percentile	$\mu\text{g kg}^{-1}$
99th	113 – 3,480
95th	10.1 – 112
90th	6.01 – 10
75th	3.01 – 6
	<DL – 3



deposits. The gold in stream sediment image for the combined survey areas is shown in Fig. 6.1, and Fig. 6.2 shows the gold in soil image for Northern Ireland (the gold results for Tellus Border soils are not yet available).

Figure 6.1. Gold in stream sediments in the Tellus and Tellus Border survey areas. Numbers signify locations referred to in the text.

BACKGROUND TO GOLD PROSPECTING IN THE NORTH OF IRELAND

Bronze Age gold artifacts discovered in the northern part of Ireland are believed to have had a local geological source (Warner *et al.*, 2010), but to date no bedrock or alluvial source of gold has been discovered that matches the trace element chemistry of the gold in these artifacts. Some Bronze Age gold artifacts were discovered in the prospective Armagh–Monaghan Gold Belt (Figs 6.1 and 6.2, location #01), but anything more than a spatial relationship has not yet been proved.

Gold has long been recognised in stream gravels from drainage networks in the foothills of the Sperrin Mountains (Boate, 1652) and work by Arthurs (1976) defined further locations where gold in significant quantities could be panned. However, almost unnoticed by the exploration community, economic grade gold mineralisation was discovered by the Mining Corporation of Ireland over mineable widths at the Clontibret antimony deposit (Fig. 6.1, location #02) in County Monaghan between 1956 and 1957 (Morris *et al.*, 1986).

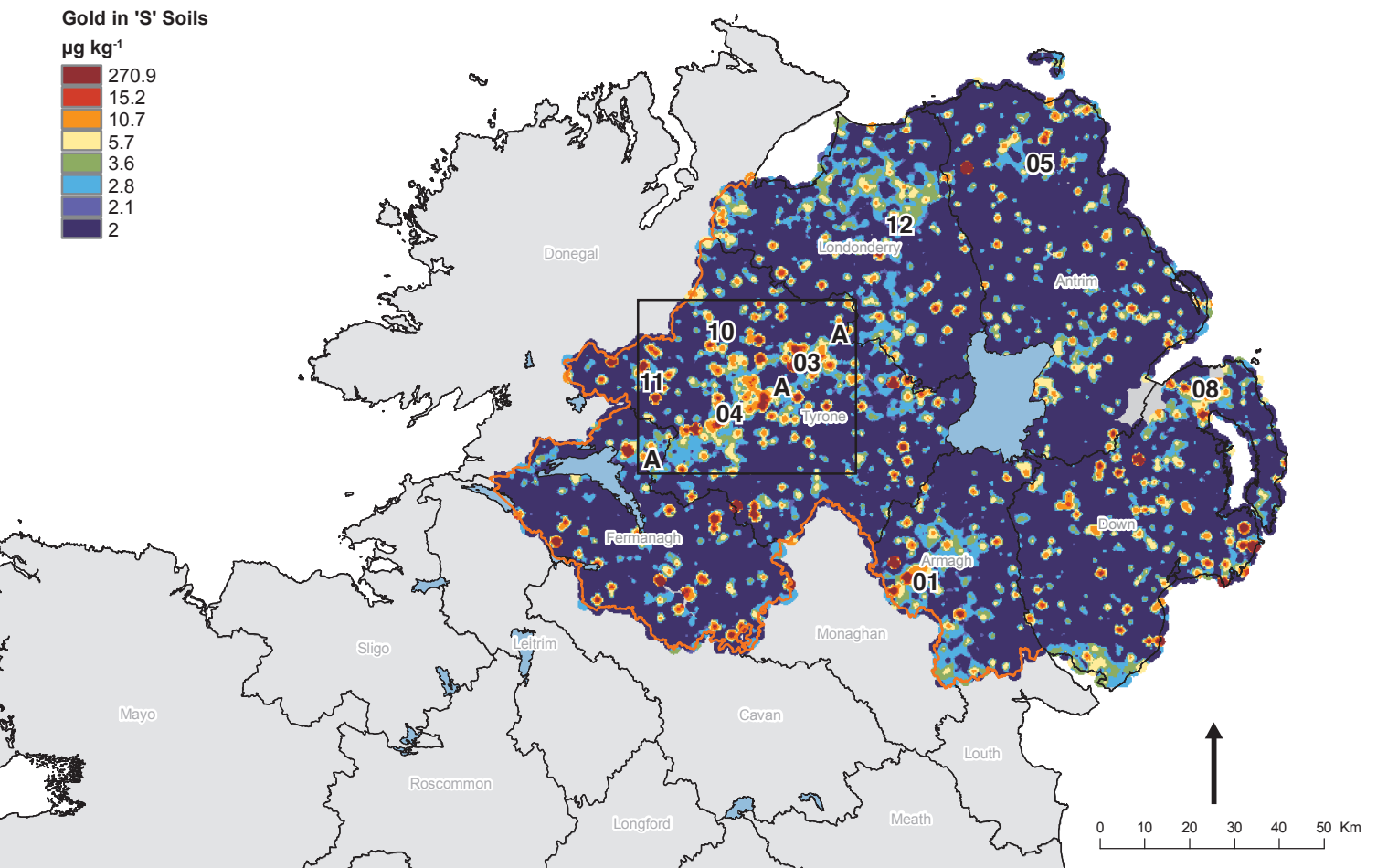


Figure 6.2. Northern Ireland: gold in subsoil. Numbers signify locations referred to in the text. A-A-A denotes the Omagh Thrust. For detail of rectangle, see Fig. 6.7.

In January 1980 gold peaked at \$850 per ounce and prompted exploration companies in Ireland to direct some of their budgets from base metals into gold. Irish Base Metals (later to become Ennex) was a leader in the gold exploration foray and the recognition that ‘the biggest anomaly in these islands is the absence of a gold deposit’ (Clifford *et al.*, 1990) provided an impetus towards discovery. Ennex’s prospecting in the Sperrin Mountains during 1982 followed up work by Arthurs (1976) and confirmed the presence of quartz–pyrite float at Glenmacofffer and quartz–arsenopyrite float in Glenlark. Analysis proved gold values of up to 12 g/t (Clifford *et al.*, 1992).

Subsequent prospecting discovered outcropping quartz–pyrite–gold mineralisation in Curraghinalt Burn (Fig. 6.2, location #03), which prompted an increase in gold exploration in the Dalradian Supergroup within the Grampian Terrane of Ireland and Great Britain. Further Dalradian-hosted deposits were discovered at Cavanacaw, west of Omagh (Cliff and Wolfenden, 1992) (Fig. 6.2, location #04) and Cononish in Scotland (Earls *et al.*, 1992), while other significant occurrences were identified in the Ordovician–Silurian rocks of counties Monaghan, Mayo and Wicklow (Morris *et al.*, 1986; Thompson *et al.*, 1992; Milner and McArdele, 1992). The estimated total resource (all categories) at the three deposits in the north of Ireland (Curraghinalt, Cavanacaw and Clontibret) now totals approximately 5 million ounces of gold, and it is likely that more will be found.

Consequently, if asked the question ‘What have been the most significant advances in economic geology in the north of Ireland over the past 40 years?’, most geologists will consider the discovery of gold in the Dalradian and Lower Palaeozoic terranes and the Tellus surveys as paramount. Informed by the knowledge of the known deposits and occurrences, exploiting the Tellus data sets therefore presents an exciting challenge for the exploration geologist.

GEOCHEMICAL SAMPLING TECHNIQUES

In the 1980s a significant amount of work was done to establish the best medium to sample geochemically for gold. Prior to the 1980s, many areas had been surveyed by soil sampling, but as the analytical methodologies available to determine gold were relatively insensitive, most companies used pathfinder elements such as arsenic to identify prospective areas for gold mineralisation.

Following the discovery of the Curraghinalt deposit, exploration companies profile-sampled the overburden and found that the optimum sampling horizon to define an anomaly related to bedrock mineralisation was immediately above bedrock (Clifford *et al.*, 1992). Shallower samples were often still anomalous but the geochemical signature was generally more dispersed or of lower concentration. With atomic absorption analysis offering detection limits of 5 ppb gold, deep overburden sampling became the geochemical methodology of choice. At Curraghinalt every deep overburden anomaly greater than 100 ppb gold was found to be related to bedrock mineralisation. However, for regional geochemical surveys deep overburden sampling is less practical and soil surveys are more cost-effective and probably reflect a wider area of geological influence. Therefore, the Tellus geochemical surveys focused on soil sampling at two depths – shallow and 0.5 m depth.

The existing company databases of deep overburden sampling and the known gold occurrences allow robust comparisons with the Tellus geochemical data. This provides a strong degree of confidence that the known deposits are reflected in anomalous Tellus soil geochemistry, and that many more occurrences of bedrock mineralisation have geochemical signatures that echo the underlying mineralisation. More intriguingly, there are numerous areas of unexplained gold in soil and stream geochemistry that still await detailed follow-up, although a study by Coulter and Stinson (2013) in the Tellus Border region was unable to relate areas of strong gold stream sediments geochemistry to significant float or bedrock gold mineralisation.

GEOPHYSICAL TECHNIQUES

The airborne electromagnetic and high-resolution magnetic surveys are valuable regional geophysical tools to use in combination with the soil and stream geochemistry. The definition provided is appropriate to regional exploration, although some companies have flown heliborne surveys at closer line spacing than used in the Tellus surveys.

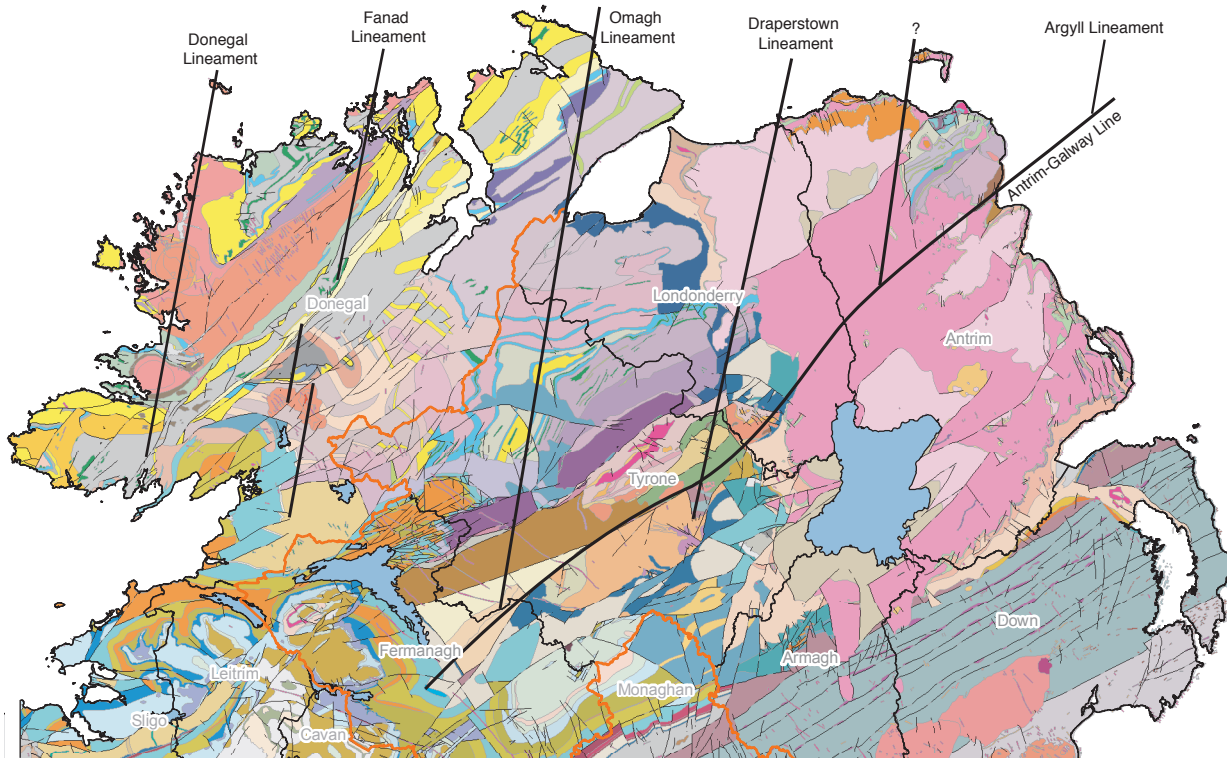


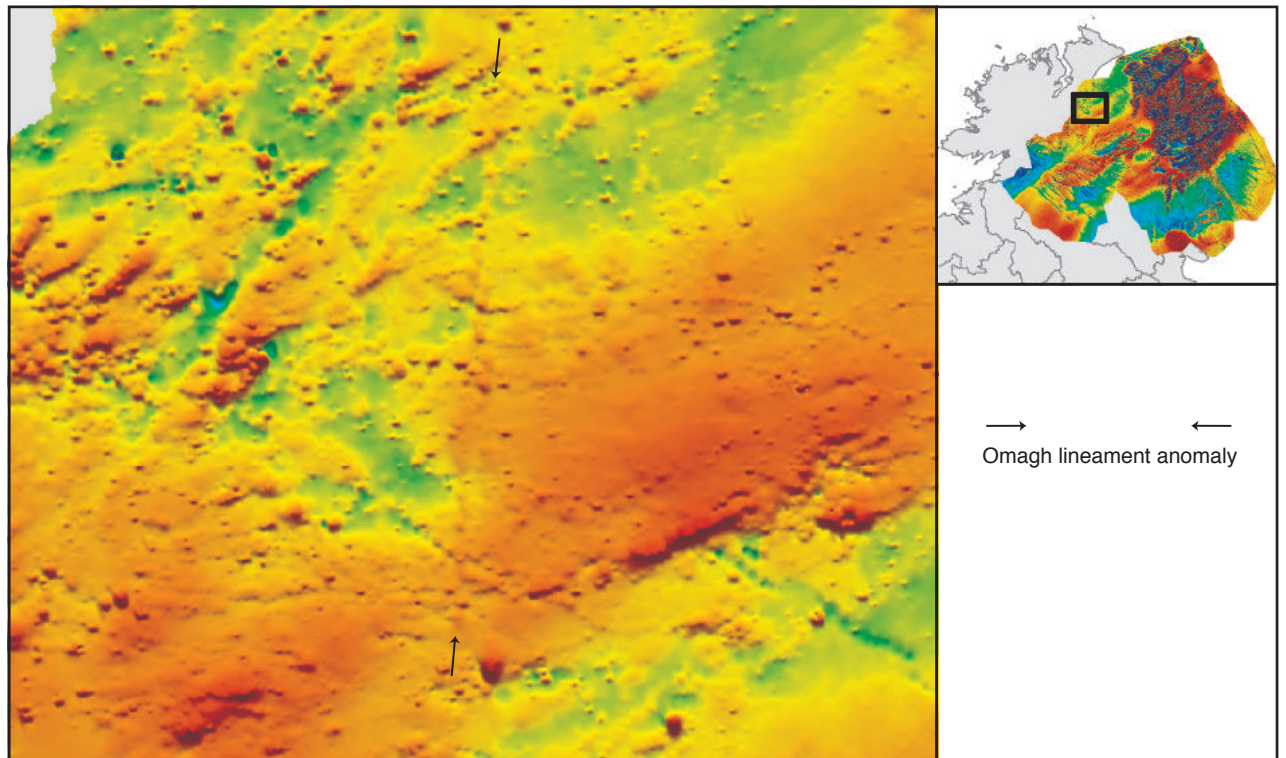
Figure 6.3. Interpreted lineaments in the north of Ireland (Earls *et al.*, 1996).

Mapping by Alsop and Hutton (1996) identified north-northeast trending lineaments in County Donegal as credible deep-seated controls on granite emplacement and Dalradian sedimentation. Earls *et al.* (1996) applied this approach to gold mineralisation in the Sperrin Mountains and established the concept of the north-northeast trending Omagh Lineament (Fig. 6.3) as a control on gold mineralisation at the Cavanacaw deposit.

The designated west-of-north flight line direction of the Tellus airborne geophysical surveys was a compromise designed (i) to be nearly orthogonal to regional strike, and (ii) to intersect the expected orientation of theoretical structures such as the Omagh Lineament at a favourable angle. The Tellus magnetic data identified a north-northeast trending linear feature where the Omagh Lineament had been predicted (Fig. 6.4). The origin of the linear magnetic anomaly is uncertain, but may reflect a dyke intruded along the pre-existing structural weakness. These observations reinforce the dictum that fieldwork, structural concepts and geophysical interpretation can usefully be integrated with a high degree of confidence in the search for gold mineralisation. Cooper *et al.* (2013) have further expanded the north-northeast trending linear model and proposed further lineaments.

THE TELLUS DATA AND KNOWN GOLD OCCURRENCES

One of the most coherent gold-in-soil anomalies is coincident with the Omagh Thrust (Fig. 6.2, A-A-A). Studies by Earls *et al.* (1996) identified this regional structure as a focus



for fluid movement during both the Silurian-Ordovician and Lower Carboniferous. Fluid inclusion studies of approximately 50 quartz vein hosted bedrock gold occurrences in the Dalradian metasediments proved a gold-bearing fluid distribution pattern associated with the hanging wall of the Omagh Thrust (Fig. 6.5). Plotting the occurrences of auriferous float in the area (Fig. 6.6) proves spatial consistency with the bedrock fluid occurrences and the Tellus gold-in-soil data also reinforce the area as prospective (Fig. 6.7). Therefore on the north-western side of the Omagh Thrust, the spatial distribution of bedrock mineralisation can be defined by two independent methods. This represents powerful evidence of the veracity of the Tellus soil data and prospecting. Figure 6.8 illustrates how faults, fractures and lithological conductors mapped by the airborne electromagnetics correspond to bedrock gold occurrences along the Omagh Thrust. Lusty *et al.* (2009) analysed the prospectivity of gold anomalies of these Dalradian rocks, using a statistical technique to integrate relevant geological, geochemical and geophysical characteristics.

The Tellus and Tellus Border geochemical surveys define the prospective areas of the Lower Palaeozoic Longford–Down terrane and more specifically the Armagh–Monaghan Gold Belt. The gold in bedrock occurrences along the Orlock Bridge Fault at Clontibret (Fig. 6.1, #02) and to the north-east in County Armagh at Cargalisgorran and Clay Lake confirm the soil and stream geochemistry. There is evidence in the region of north–south structures and it is possible that the southern extent of the Draperstown lineament may

Figure 6.4. North-northeast trending magnetic anomaly coincident with the Omagh Lineament.

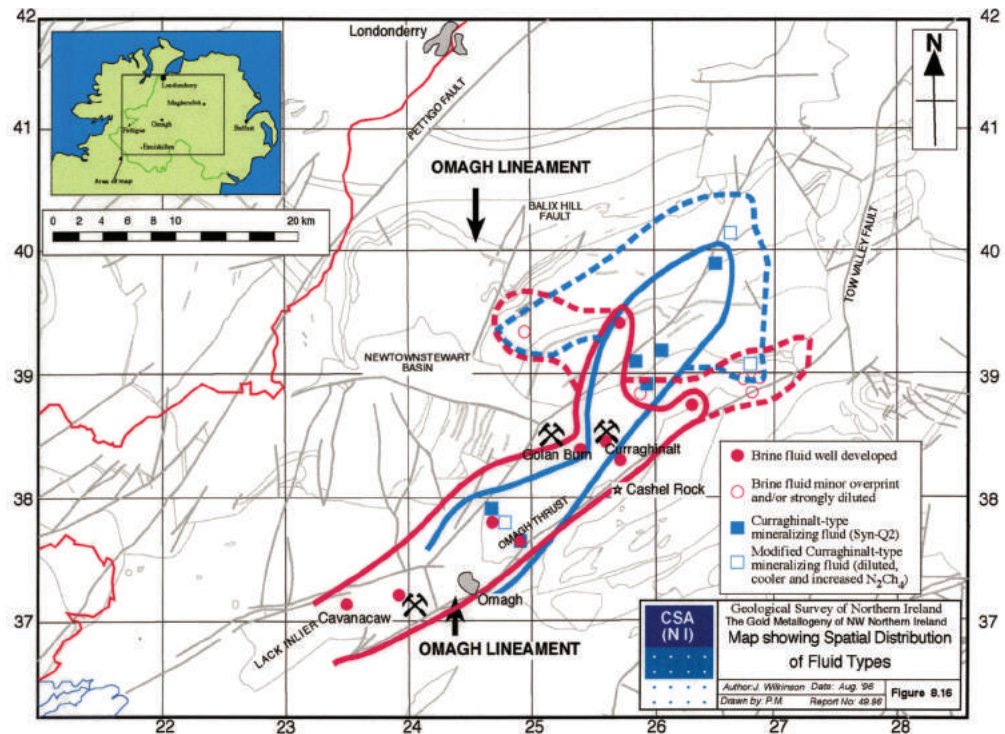


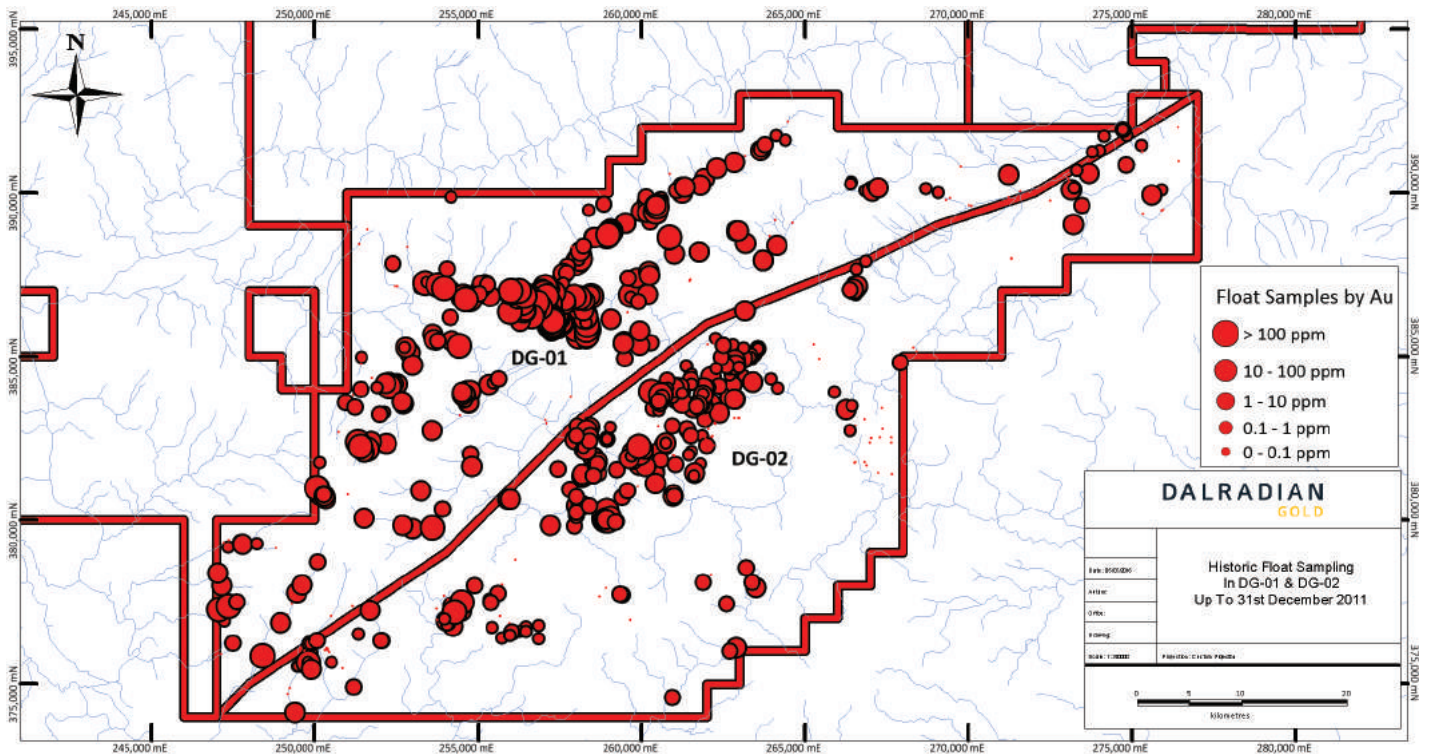
Figure 6.5. Fluid inclusion data from bedrock samples in the vicinity of the Omagh Thrust (Earls *et al.*, 1996).

trend through this area. Fluid inclusion evidence proves that ‘Carraghinalt-type ore-forming fluids’ are present along parts of this lineament (Earls *et al.*, 2000). Lusty *et al.* (2012) have delineated targets in the Longford–Down terrane by a statistical analysis of several significant parameters.

Thus in Lower Palaeozoic rocks the evidence is supportive of the soil and stream geochemistry in County Armagh and the stream geochemistry in County Monaghan (soil samples remain to be analysed) reflecting significant bedrock occurrences.

Prospecting in the 1980s also discovered gold mineralisation in north-east County Antrim at Belladoo Bridge (Fig. 6.2, #05) (Clifford *et al.*, 1987). Whereas most of the occurrences in other areas were cross-cutting, the Belladoo Bridge discovery is strike-parallel and occurs in lithologies interpreted as similar to the strike-parallel gold-enriched outcrops at Glenlark in the Sperrins. The Tellus soil geochemistry is mildly anomalous in north-east Antrim, but not in the vicinity of the known bedrock mineralisation. At Glenlark, the Tellus gold in soil geochemistry is also only weakly anomalous. Based on this evidence, diligent prospecting for gold requires detailed structural and stratigraphic knowledge in addition to the Tellus geochemistry.

In County Sligo prospecting in 2012 discovered quartz–pyrite float in the Ox Mountains (Fig. 6.1, location #06) that assayed up to 9.8 g/t gold. The Tellus Border stream sediment data are anomalous in gold in the vicinity of the float sample locations, and although



the float was discovered before the Tellus Border results were released it is further support that the stream sediment results reflect gold mineralisation.

In north-east and east County Donegal, stream sediment anomalies are related to known alluvial occurrences at Quigley’s Point (Fig. 6.1, location #07) and at least one bedrock occurrence at Cross Bridge in Inishowen (Moville Minerals, 1996).

AREAS OF EXPLORATION POTENTIAL

North Down

In north County Down elevated gold values are present in both soils and stream sediments (Fig. 6.2, location #08). On receiving the first unexpectedly promising results of the Tellus soil sampling in this area, it was decided to repeat sampling wherever the high gold concentrations were present. The repeat samples and subsequent analyses confirmed the initial large-scale soil anomaly. Academic studies and sampling of the spoil heaps from old lead mines in the region have failed to provide evidence of bedrock gold mineralisation.

Geologically, north County Down is a broad analogue of the Armagh–Monaghan Gold Belt but no modern exploration has taken place in the area. The proximity to the Orlock Bridge Fault and the presence of north-northeast trending structures (which may be related to an interpreted deep-seated linear) are encouraging features. Detailed soil

Figure 6.6. Distribution of gold float from prospecting in the vicinity of the Omagh Thrust. (The licence boundary between DG1 and DG2 marks the Omagh Thrust.) Image courtesy of Dalradian Resources.

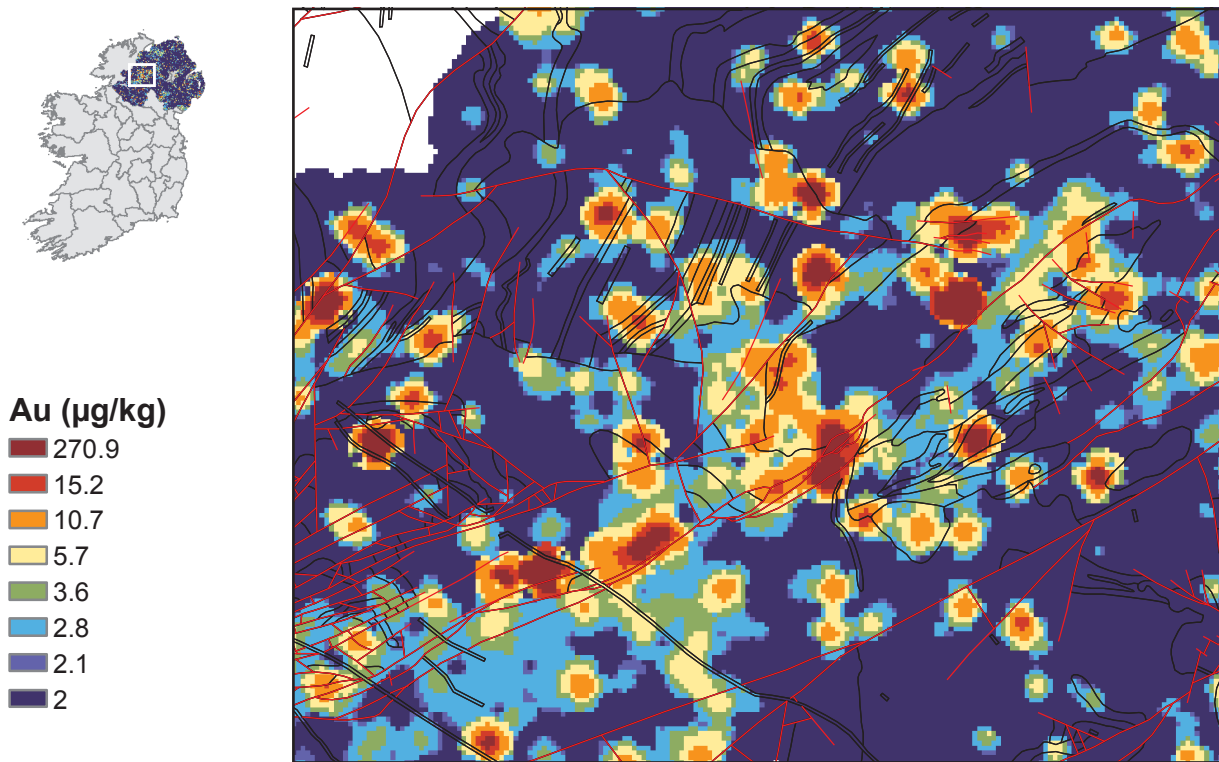


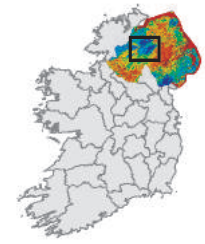
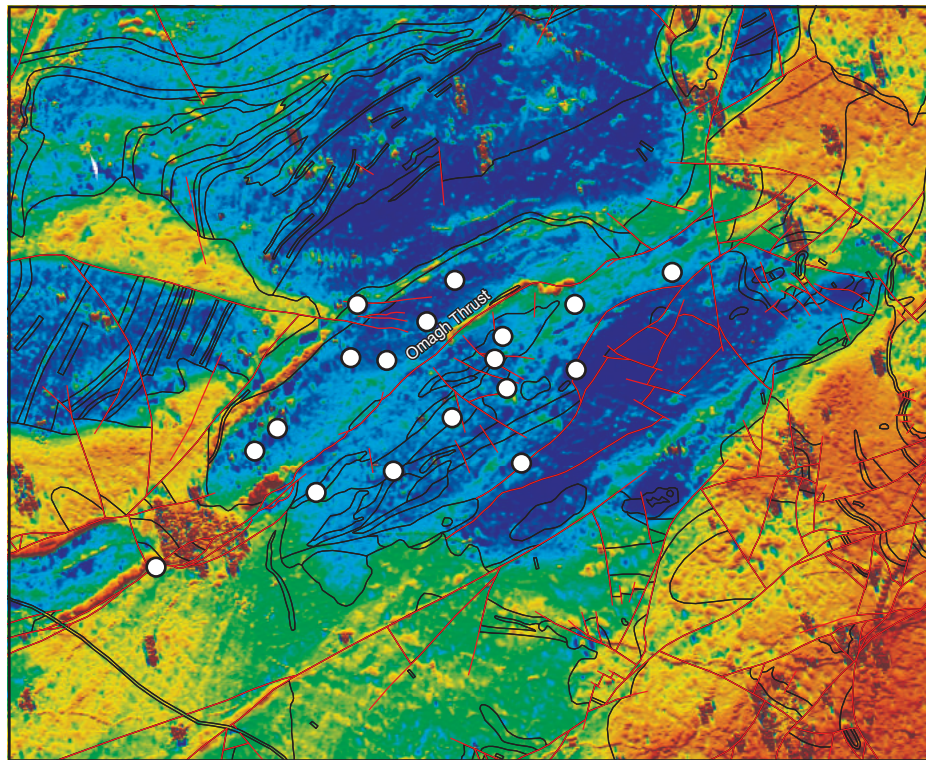
Figure 6.7. Detail of gold in soil anomalies in the vicinity of the Omagh Thrust (for location see Fig. 6.2).

sampling, prospecting and structural analyses as undertaken in counties Armagh and Monaghan would be the best way forward in this region.

Monaghan and Cavan

Elevated gold in stream sediment values occur in the Lower Palaeozoic lithologies in the eastern parts of counties Monaghan and Cavan. They are confined by the Caledonian and Palaeocene granites of Newry and Slieve Gullion to the north-east and by the faulted Kingscourt Inlier to the south-west. The distribution pattern of the anomalous stream sediments (Fig. 6.1, location #09) is reminiscent of the Armagh–Monaghan gold belt, which lies some 20 km to the north-west.

The Kingscourt Fault is not visible in the Tellus geophysical data, but corresponds to a linear feature on the Bouguer gravity anomaly map of Ireland, and is interpreted as a deep-seated structure (Readman *et al.*, 1995). The proximity of the stream sediment anomalies to the northerly trending Kingscourt Fault is encouraging. Strong rheological contrasts will occur between the Moffat Shale Group and the Silurian greywackes and should facilitate fluid flow.



○ Bedrock Gold Occurrence

Tyrone and Londonderry

The extent of bedrock gold occurrences discovered in Counties Tyrone and Londonderry in the 1980s is reflected by the Tellus soil geochemistry. Many of the Tellus soil anomalies can be interpreted as related to bedrock occurrences and have previously been surveyed by regional geophysics and geochemistry carried out by industry. However, there are several Tellus anomalies to the north and south of the Newtown Stewart Basin (Fig. 6.2, location #10) that have no known bedrock gold source. This area is underlain by the Dungiven and Newtown Stewart formations and is coincident with the Omagh Lineament. Conceptually, this represents a promising target area in a zone of structural complexity, with varied compositional lithologies providing strong rheological contrasts.

To the south-west of Castleterg, County Tyrone there are three groupings of single site gold in soil anomalies (Fig. 6.2, location #11), each of which aligns in a north-northeast orientation. The area is mapped as heavily faulted and comprises the Claudy, Aghyaran and Killeter Quartzite formations. Stream sediment sampling supports the easternmost soil anomaly, as does antimony in soils. This entire area is marked by a well-developed arsenic soil anomaly.

There are no publicly recorded bedrock occurrences of gold in this part of Northern Ireland. However, considering the geology in context with the anomalous stream sediment

Figure 6.8. Electrical conductivity in the vicinity of the Omagh thrust and bedrock gold occurrences (white dots).

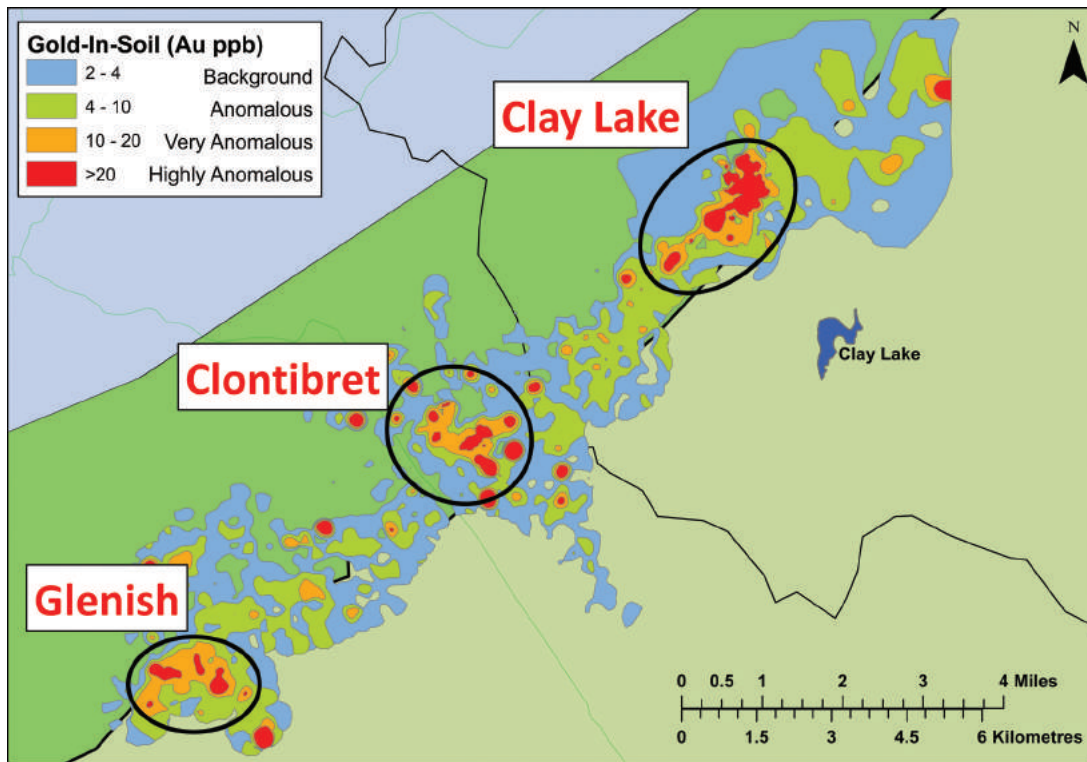


Figure 6.9. Detailed gold in soil sampled along a 21 km trend by the licence holder in counties Monaghan and Armagh. Image courtesy of Conroy Gold and Natural Resources plc.

pattern in the adjacent County Donegal lithologies supports the idea that it should be considered as a single trend.

County Sligo

In County Sligo the float boulders discovered in 2012 (Bowpark Exploration, 2012) (Fig. 6.1, location #06) have stream sediment support from the Tellus Border data. There are other stream sediment anomalies in the Ox Mountains area that still require explanation.

Geologically the area is a general analogue of the Curraghinalt and Cavanacaw deposits in that it lies on the northern margin of a major Caledonian structure and is also proximal to the southern projection of the Donegal lineament of Alsop and Hutton (1996). Occurring close to the intersection of two major structural trends and with igneous activity associated with the Caledonian Avalonia-Laurentia collision potentially providing both fluids and a heat source, the area is considered very prospective.

Draperstown lineament and Slieve Gallion

The lithologies overlying the interpreted Draperstown lineament represent the most varied geology in Northern Ireland. This is evidenced by the strike swing in the Tow Valley fault, the location of the Ordovician Slieve Gallion Granite, and the zones of north–south faulting in the Mesozoic and Lower Palaeozoic lithologies.

Sporadic, and in some places moderately coherent, elevated gold in soil anomalies occur over the trace of the lineament (Fig. 6.2, location #12). Earls *et al.* (2000) established that similar gold-bearing fluids involved in at least some of the gold precipitation at Curraghinalt also occur in the vicinity of the Draperstown lineament. Consequently it would be worthwhile to investigate some of the anomalies.

Limited exploration for volcanogenic massive sulphide (VMS) mineralisation has been undertaken in the Slieve Gallion Inlier (Fig. 6.1, location #13). Recent work by Hollis *et al.* (2015) is suggestive of gold-rich VMS potential associated with ironstones (VMS chemical exhalites). Historic prospecting results associated with the ironstones include mineralised float (3% zinc, 0.23% lead, 0.15% copper and 23 ppm silver) and one of the ironstones corresponds to a Tellus magnetic anomaly (most visible on the Total Magnetic Intensity-tilt and First Vertical Derivative transformations), which extends for ~400 m along strike. Elevated gold in stream sediments and soils is also found locally.

County Donegal

In south and north County Donegal elevated concentrations of gold in stream sediment samples are related to the Termon Pelites, the Slieve League Formation and Slieve Tooley Quartzite (Fig. 6.1, #14). In Inishowen, the angular form of gold panned from the Quigley's Point drainage system is strongly suggestive of a local source (Moville Minerals, 1996). Given the extent of geological study and the exploration history for a wide range of commodities, it is surprising that more bedrock gold occurrences are not recorded.

The release of the Tellus Border data has stimulated an uptake in prospecting licences in Donegal. Considering the quality of existing geological mapping, it is anticipated that systematic exploration will discover bedrock sources for the many gold anomalies in the county.

CONCLUSIONS

1. The north of Ireland in general, and Northern Ireland in particular, is covered by world-class geochemical and geophysical data sets which facilitate gold exploration. When the Tellus Border soil samples are analysed for gold, the data coverage will be almost unrivalled.
2. There is a high level of confidence that in the Dalradian and Lower Palaeozoic terranes of Northern Ireland the soil geochemistry is reflecting bedrock gold mineralisation.
3. The Tellus data can help to guide and focus exploration programmes, but new discoveries are most likely to be made by applying experience and geological knowledge to specific sites. Time spent prospecting and mapping on the ground allied with a strong conceptual understanding of mineralisation processes is essential for optimising the value of the Tellus information.
4. Many anomalies remain to be followed up by ground mapping, prospecting and more detailed sampling.

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