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# AMULSAR 3D GEOLOGICAL MODEL REVISION:

# SUMMARY AND RESOURCE IMPLICATIONS

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LYDIAN
RESOURCE COMPANY

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# AMULSAR 3D GEOLOGICAL MODEL REVISION SUMMARY AND RESOURCE IMPLICATIONS

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**Purpose of report**: *To summarise the results and resource implications of a recent remodelling of the Amulsar geology based around the new drillhole lithochemistry analysis and the new 2013 drilling data.*
*The digital modelling data supplied consists of 107 modelled rock unit solids wireframes and 11 modelled groups of fault wireframes.*

## EXECUTIVE SUMMARY

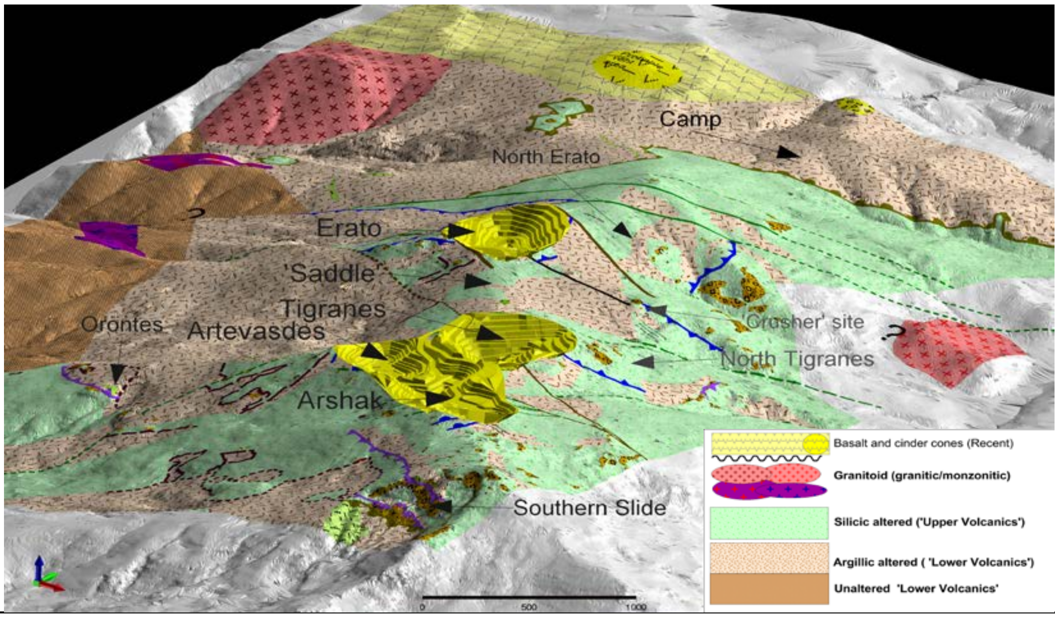
The existing 3D model of Amulsar has been reviewed and revised following the 2013 drilling results and the production of a new lithochemical discriminant (by Dr Nick Oliver) that provides a more robust tool for identifying RC rock chips. Significant changes were made to the model in the Erato and Arshak areas, but only minor changes made to the existing model at Tigranes. Artavasdes was not included in this review and will be remodelled in-house, but changes there are expected to be minimal.

The strong relationship previously noted between resource and complex structuring is reconfirmed, but the new model provides much greater definition of both the resource-related structures and the later graben structures that contain the resource volume (and that locally segment the resource). In particular, resource at both Tigranes-Artavasdes and Erato is related to a central steep NW-trending fault, and to multiple low angle (thrust?) structures in adjacent rock volumes.

It is known from the drilling results that there is resource below the current pit shell designs in each of the pit areas. The modelling shows that the complex structures hosting significant gold grades project to well below the current pit shells, and that the basal argillic andesite body has not yet been intersected by drilling below either the Erato or Tigranes-Artavasdes pits, but may have just been reached below parts of Arshak. At Arshak however there is still resource potential below the edges of the current pit design. At both Erato and Tigranes the zone of complex structures has been inferred to project to at least double the current pit design depth. However, the complexity of the resource-bearing structures is such that such large extrapolation needs to be treated with great caution.

The 2013 drilling at North Erato has provided sufficient data to be able to model that northern margin reasonably confidently. In particular, a major NE-trending graben fault truncates the Erato system to the northwest. However, this normal fault has a throw that is inferred to be of the order of 500m, and thus there is likely to be significant volumes of potential resource host beneath Erato. The graben fault marking the northern margin of Tigranes is also a major south-block-down graben fault. It is not known at this stage whether that fault deepens the graben system even further to the south (thus presenting a greater volume of potential resource host) or whether there has been a complementary fault between Erato and Tigranes that would define an uplifted horst block in that gap area. In the latter case, the resource volumes at Erato and Tigranes-Artevasdes will be comparable.

Several fault systems are identified from the model that would have an impact on the current pit design (both positive and negative).




***View of Amulsar** looking down to the northwest showing localities mentioned in this report and the locations of the existing pit design. Gold is dominantly hosted in the volcaniclastic rocks shown in green; the clay altered rocks shown in buff colours (dominantly porphyritic andesite, with minor volcaniclastics) form the main units for modelling the geology.*

## INTRODUCTION

A 3D geological and structural model for Amulsar was produced early in 2013 following intensive field mapping and core relogging during 2012. The result was the recognition of considerable local structural complexity resulting from superposition of multiple sets of structures dominated by faulting: These structures include pre-mineralisation brittle-ductile thrust-folding; a syn-mineralisation complex of brittle linked strike-slip faults, local thrusts, and folds; and post-mineralisation large-scale extensional horst-graben faulting.

The 3D geological model is concomitantly complex. However, the rock units used to define the geological model are very simple; a two-part division of the local rocks into siliceous host-rocks (dominantly volcanogenic sediments) and clay altered rocks (dominantly porphyritic andesite) that are generally devoid of mineralisation. These two alteration-based lithologies are thought to reflect primary rock unit differences although the original stratigraphic relationships between them are uncertain and blurred. The clay-altered rocks form sheet-like bodies of various thicknesses distributed throughout the silica-altered host rocks, and where bedding can be defined in those rocks, the sheets are parallel to that bedding. That is, they have a systematic sill-like form within the host sequence, which allows them to be used to define the internal structure. The 3D modelling is based on defining the geometry of these clay-altered units (LVA), leaving the geometry of the host sequence (VC) to be inferred by subtraction[1]].

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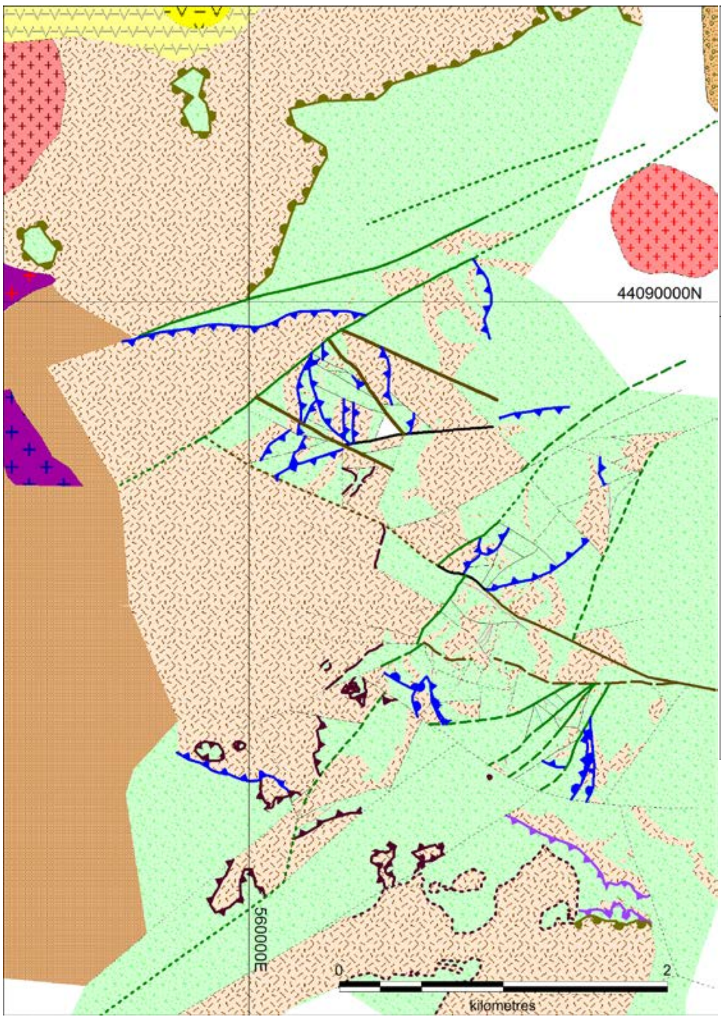
[1] The uncertainties expressed in this paragraph arise from uncertainties in the observed relationships and the strong thrust-related structuring revealed by the modelling. Many, but not all, of the contacts of the clay-altered rocks are layer-parallel faults, and not all of the clay-altered rocks are intrusive porphyritic andesite (such as the coarse volcaniclastic conglomerate forming the clay-altered bodies at Orontes). Thus there is the possibility that some panels may be structurally emplaced. However, following field and core examination during 2013 by Dr Nick Oliver ('*Amulsar Armenia, Hydrothermal System Appraisal*', NHS Oliver, August 2013), the current belief is that the porphyritic andesite bodies were originally intrusive into the host sequence.

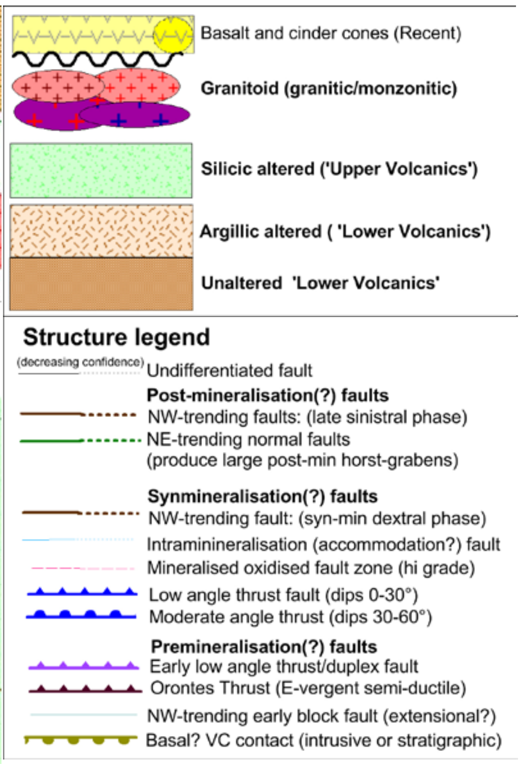
The structural complexity produces additional complexity in resource modelling and accuracy of the 3D geological model becomes an important issue. Reliance on the accuracy of the geological model is particularly true with the lower level resource categories where there is a greater dependence on the geological model for resource extrapolation. Thus the geological model is highly dependent on the accuracy of core logging, and requires strong QA/QC monitoring and constant revision as new drilling data is produced.

This report describes an update of the 2012 geological model developed following the 2013 drilling season, and the development, by Dr Nick Oliver, of a geochemical discriminant that assigns each assay interval to lithochemical units corresponding to the two major rock types used in the modelling. In particular, the use of the lithochemistry allowed a more confident and robust analysis of the RC logging than was available for the previous model (see Appendix: Methods). Consequently, in both Erato and Arshak where there was considerable reliance on RC data, the model was completely reworked. In Tigranes, Orontes, and peripheral areas, the previously model was checked and adjusted where necessary but required changes were minimal. Artavasdes was not checked or remodelled in this exercise (but will be done in-house) but the existing model in that that area is thought to be relatively stable.

## CURRENT MAP AND SELECTED SECTIONS

The annotated sectional views shown in this report show only the modelled LVA panels. Fault blocks without any observational data (core or surface) have not been modelled although the inferred lithology of the block is inferred on the geological interpretation map. The accompanying VC volume enclosing the panels will be modelled in-house and is not shown here. The Artavasdes area will also be modelled in-house and only the LVA contact

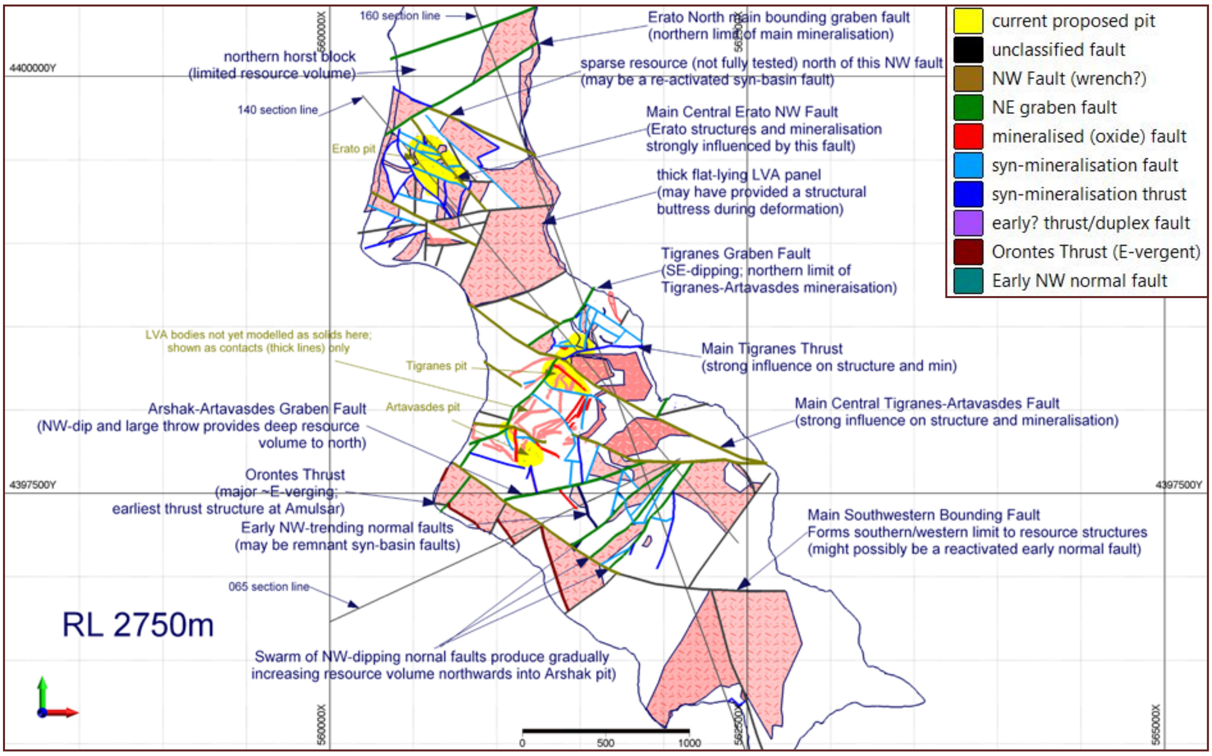



*Surface geological map. The location of contacts is based on both surface outcrop mapping and the projection of 3D modelled contacts onto the DTM surface.*
***Note** that the Orontes Thrust is a new name for a structure previously called 'Top andesite décollement'.*

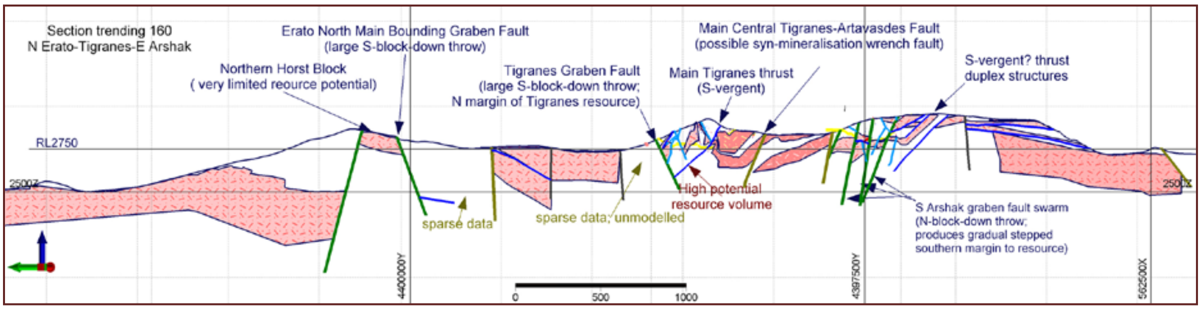
surfaces is shown in these figures (by thick buff lines).

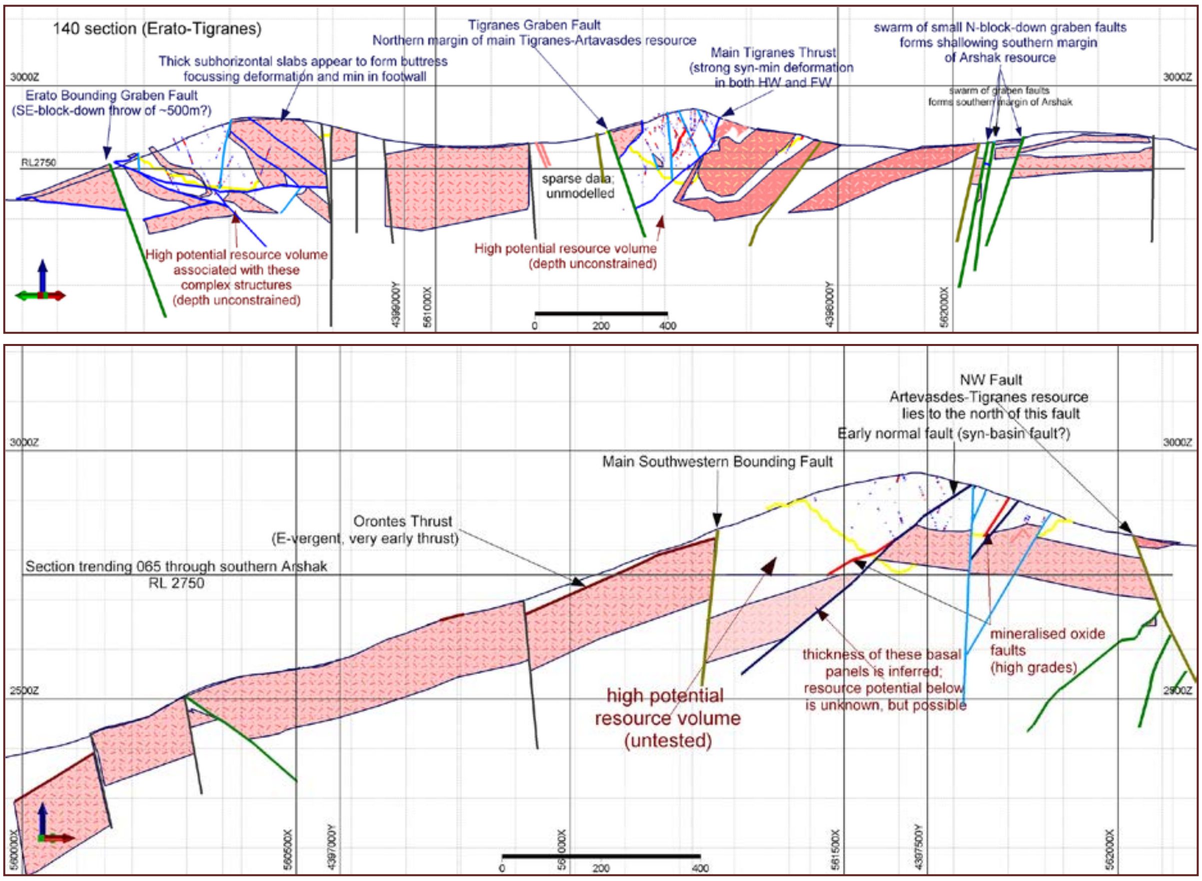
The figure on the previous page is the interpreted surface geological map produced from both the 3D model and the surface mapping. The figure below is an annotated horizontal plan section at RL2700 of the modelled LVA panels showing the location of the vertical sections. Because of the strong topographic relief in the area, this plan section is better than the surface map for showing the orientation and shape of the abundant shallowly dipping faults.




*Horizontal plan section at RL2750 showing the distribution of modelled LVA panels and faults defining the fault blocks. LVA has not been yet remodelled in Artavasdes and the contacts modelled in 2012/13 are shown by thick buff lines. Artavasdes has a fault-fold distribution similar to Tigranes. The colour legend refers to the colours of the faults shown, and is the same for all subsequent plots.*

The following figures are sections selected to highlight particular features. Because of the structural complexity no single section shows all of the relationships clearly. The long-section trending 160 best shows the effects of the syn-mineralisation thrust-fold structures. The long-section trending 140 through Erato and Tigranes best illustrates the late horst-graben faults that segment the system and expose the resource rocks in the deep grabens. The 065 section lies south of the main graben block and best shows the gentle arching and structures resulting from E-W movements. These include early normal faults and the Orontes Thrust, a major early E-vergent thrust ramp. The sections also show both the current pit outlines (yellow) and the distribution of resource-level gold grades (0.3-0.75-8->8 ppm) plotted on drill strings within a ±25m window each side of the section.



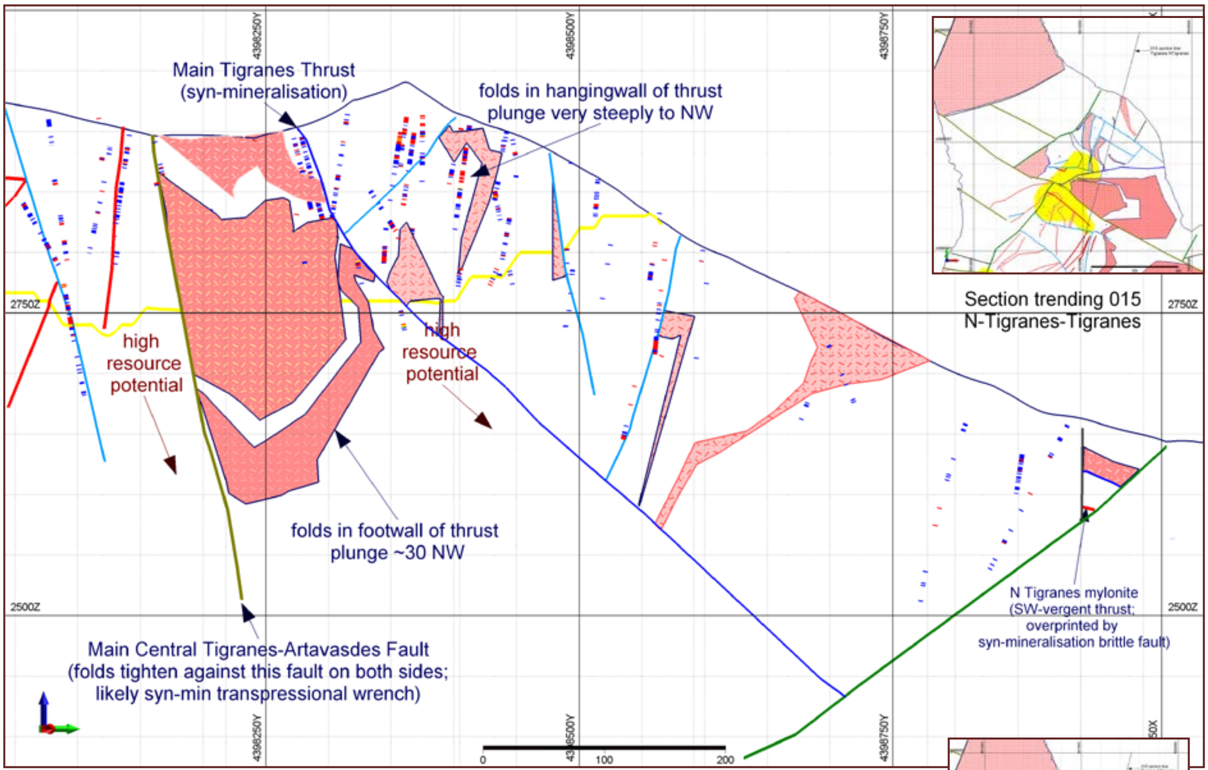


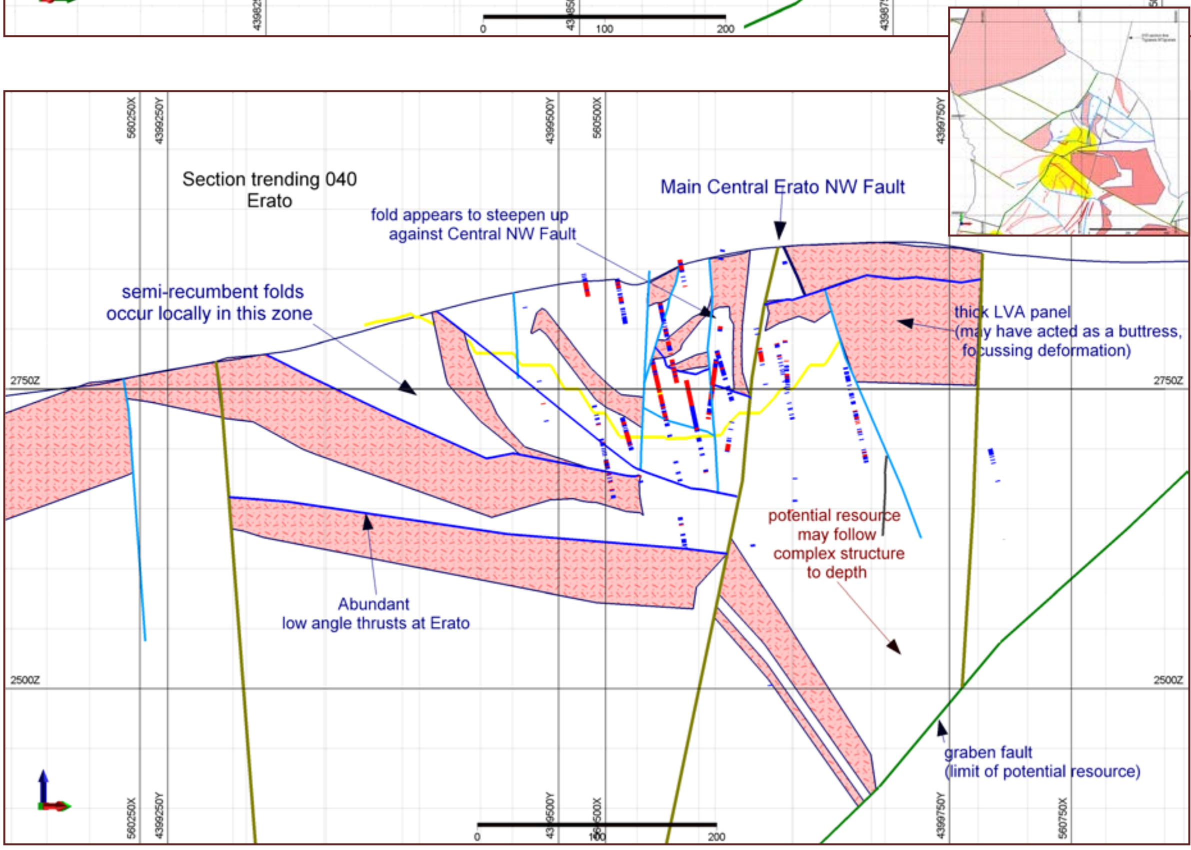

***Previous page:*** *Section trending 160 through Tigranes showing the transition from simple stacked LVA panels into complex fold-thrust structures in the strongly mineralised area. This section passes east of the mineralisation at Erato.*

***Top:*** *Section trending 140 through both Erato and Tigranes at a slightly greater scale than in the previous figure. The figure well illustrates the structural complexity accompanying mineralisation and the potential for deep level resource within .these structures well below the current pit levels.*

***Bottom****: Section trending 065 through southern Arshak from low on the western flanks near Orontes. The fault labelled Southwestern Bounding Fault curves around the southern and western margin of the main resource blocks. The top of the thick semi-continuous panel of LVA modelled to its west is poorly defined by sparse drilling and scattered surface outcrops (although it is well defined at Orontes just to the north of this section). The 150m thickness shown for that panel is conjectural. The 80m thickness of the semi-continuous panel shown to the east of the bounding fault is also poorly constrained but based on some drilling constraints in adjacent fault blocks. Although this 80m thick panel looks as if it might correlate with the thicker western panel, it is more likely to correspond to a higher sheet, such as the 80m thick panel at Erato. That is, the thick basal panel probably lies well below the 80m panel in the mineralised fault blocks. As seen at Erato there is some possibility of resource below the 80m panel where it encounters structural complication.*

The following vertical sections show details of the variably tight, and variably oriented, folding associated with strong mineralisation at Tigranes and Erato. It is unlikely that these are ductile folds, but rather brittle structures in which the fold shape is accommodated by intense local faulting. Similar folds exist at Artavasdes. In each case they show spatial differences relative to with both the steep NW fault in each pit, and the low angle thrusts that flank those faults.




***Top***: *Section trending 015 through Tigranes and into North Tigranes. Note the upright folds that tighten against the Main Central Tigranes-Artavasdes Fault, yet have quite different fold plunges in the hangingwall and footwall of the large low angle thrust. That is, the folds seem to have a spatial relationship to both structures, reinforcing the idea that the steep and shallow structures are linked.*
***Bottom***: *Section trending 040 through the most productive part of Erato. The VC rocks to the west appear to be underthrusting the thick shallowly dipping LVA slab along a series of very low angle thrusts, locally with associated semi-recumbent folds. Upright folds appear to have formed against the thick LVS slab, reinforcing the concept that this slab may have acted as a buttress during deformation*

## DISCUSSION

In all of the sections shown above, the LVA panels modelled within the zone of drill data have been extrapolated to considerable depth into the inferred zone below the zone of moderate confidence. The extrapolation, commonly to a bounding structure, is based on structural viability. However, Amulsar is noted for extreme structural variability, so the lower inferred parts of each section should be treated with extreme caution. They provide a reasonable indication of what the structure would look like if not intersected by structures not yet detected.

The modelling is based around defining the major fault architecture and then modelling all of the LVA bodies within each fault block independently (see Appendix: Methods). Although modelled independently, some LVA panels can be followed through multiple fault blocks. It is clear that prior to the deformations producing the locally complex fold-thrust geometry, there was a set of at least four LVA bodies interleaved within the VC host (irrespective of the mechanism by which they were interleaved). These panels include an 80-100m panel(s); a 40-50m panel(s); one or more 20-30m panels and one or more 10-15m panels, and the thickness seems to increase structurally downwards. At the base of the known VC host rocks is a body of LVA whose thickness is unknown but exceeds 150m thick. That body is only recognised in the peripheral areas, and does not yet seem to have been intersected within the main graben blocks.

In a number of instances panels can be correlated across block boundaries, and in a number of cases these produce fold-like structures defined by the relative rotation of planar panels. These are non-ductile folds produce by the linkage of brittle faults. In the core of the main mineralised zones of Tigranes, Artavasdes, and Erato, tight fold structures occur within fault block panels. Although these may look like ductile structures at the scale of the model, they are most likely the product of intense brittle folding accommodated by abundant faults. It is likely that this intense zone of small scale accommodation faulting is the reason that these folded zones are strongly mineralised. In all cases the folds are spatially related to steeply dipping NW faults; they appear to tighten and steepen against these faults. This suggests a dynamic linkage between the folds the thrusts and the NW faults. It is likely that the steep faults are wrench structures with a degree of transpressional contraction across them.

The amount of low angle faulting apparent through the model has been surprising, but perhaps accounts for the difficulty in producing a viable geological model over several years. The low angle faults intersect, or are intersected by, the abundant steeply dipping faults. The result is to divide the entire volume of resource rock into cube-like blocks bound on all sides by faults. A large number of the faults labelled ‘intra-mineralisation faults’ terminate on low angle fault structures. These may be earlier faults that have been truncated and translated on the thrust fault, but it is also quite possible that many of these steep faults are synchronous faults linked kinematically to the low angle structure. The fact that they don’t project to depth beyond the low angle structure complicates the modelling.

There are two main groupings of low angle thrust structures. The earliest thrust structure is the east-vergent ductile-brittle Orontes Thrust that is exposed near Orontes and locally along the western flank of Amulsar. The remaining low angle faults appear to be associated with syn-mineralisation structures and have variable dips with variable vergence.

The western flank of Amulsar is essentially a dip slope on the Orontes Thrust, which appears is a hangingwall ramp transporting both steeply dipping VC rocks as well as at least one parallel LVA panel. This has the attributes of a major fault with a ~20m zone of cleavage and drag folding above the fault, and consistently steep geometry in the hangingwall. Its tilted geometry (16-20° dip) suggests that it is lying piggyback on another thrust ramp at depth, so this east-vergent deformation would appear to be quite substantial, and will have a marked influence on the very deep geometry below Amulsar. The Orontes

Thrust is significant enough that it should have propagated into the zones of mineralisation, but away from the western flanks it is masked by the later fault structures. It is likely that some of the pre-mineralisation complexity in the mineralised area initiated as thrust-related folding or duplexing associated with the Orontes Thrust.

The numerous thrusts and steep reverse faults associated with the mineralisation dip dominantly either west or east, with a subset dipping to the north, and the dips tend to be lower at Erato (<30°) than in the southern areas, where dips on these structures tend to be in the range 40-60°. The variable dips and vergence is consistent with these being local accommodation structures, rather than reflecting a regional trend. One of these structures, a very shallowly dipping west-vergent thrust, displaces the Orontes Thrust with a throw of about 100m at Orontes.

**RESOURCE IMPLICATIONS**

The 2012 work showed that gold resource at Amulsar is strongly structurally controlled, lying within a large envelope of pervasive interlinked fractures around areas of abnormal deformation. There is a clear linkage between structural complexity and resource; the greater the degree of structural complexity the greater the resource.

The present modelling reconfirms that association between resource and structural complexity, but details of the structures are better defined. Although there is a broad envelope of rocks with grade, the greatest concentration of resource at Tigranes-Artavasdes and at Erato is spatially associated with both a central NW-trending steep fault in each area and one or two large shallowly dipping thrust structures that may be linked to the steep fault. In each instance the rocks (LVA panels and VC host) show apparent fold structures (of variable plunge) close to the shallow faults.

The critical resource implication from the modelling is that the structures apparently associated with mineralisation continue to depth below the current drilling levels, and provide a significant resource potential well below the currently proposed pit levels. Exploration should target the volumes around both the steep NW-trending central faults, particularly near low angle faults. Structural complexity is paramount to the production of resource; and signatures of that complexity will include abnormal fault intervals, and extreme difficulty in extrapolating geology between adjacent holes.

The new data has modified or redefined the faults labelled ‘Mineralised Oxide Faults’ at Arshak and Erato. These faults (shown in bright red on the map and sections) do not always produce significant displacement but are distinctly planar zones (of variable orientation) defined by either oxide-rich fault intervals or narrow high grade intervals in the drill strings. They are high grade resource targets in their own right.

The 2013 drilling at North Erato has provided sufficient data to be able to model that northern margin reasonably confidently. In particular, the fault shown as the Erato North Main Graben Bounding Fault is a major NE-trending graben fault that truncates the Erato system along its northwestern margin. This normal fault has a throw of perhaps as much as 500m inferred from the assumed correlation and offset of one of the low angle thrusts. Thus the graben to the south of this fault is likely to expose significant volumes of potential resource host beneath Erato. The Tigranes Fault, forming the northern margin of the Tigranes-Artavasdes system, is yet another south-block-down graben fault with significant throw (>250m). Thus if the ‘gap’ between Erato and Tigranes is not a horst block, then the depth of potential VC host beneath Tigranes is increased further. A complementary north-block-down fault that would define a horst block has not yet been recognised between Erato and Tigranes (although one is expected).

Thus the major graben faults have throws of well over 300m, and what has become clear from the modelling is that in both the Tigranes-Artavasdes and Erato pits the thick (>150m) basal LVA unit has not yet been reached. In southern Arshak it is possible that the thick basal unit has been intersected in the deepest drilling. However, even at Arshak there is still considerable volume of potential resource below the edges of the current pit design.

**GEOMECHANICAL AND PIT DESIGN IMPLICATIONS**

The faults shown on the map and in the model are only those truncating or producing significant off-sets on the LVA bodies. The only exception is the fault set labelled ‘Mineralised Oxide Faults’ (see above). There is an abundance of other fault intervals shown in the core logging that will reflect a huge number of minor faults. This is to be expected where brittle processes have had to accommodate folding. However some of the larger faults modelled will have an impact on pit design, and ultimately mining practice.

Most importantly there is a pair of low angle faults along the western side of the current Erato pit design that will have to be accounted for. These dip shallowly into the pit with orientations conducive to wedge failure.

A swarm of moderately steeply dipping normal faults (graben faults) spaced about 100m apart cross the southern margin of the Arshak pit. These faults dip about 60° to the NW and control step-ups in the resource volume toward the southern pit margin. They will certainly have to be accounted for geomechanically, but it is possible that the favourable dips may aid the pit design.

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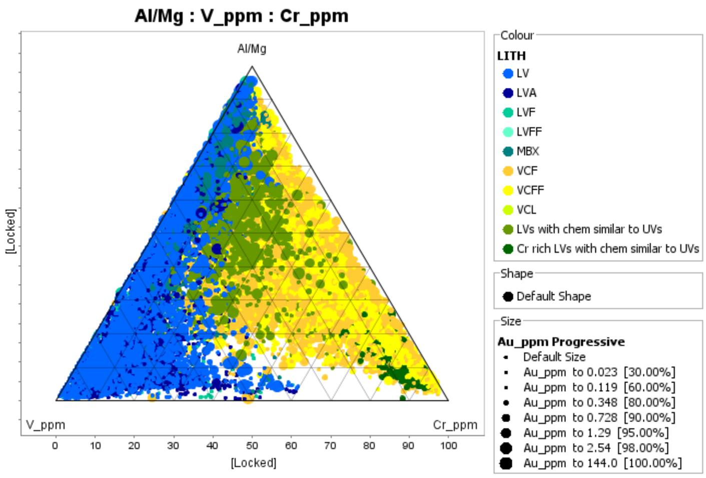
The scientific and technical analysis in this report that relates to the geology of the deposit has been compiled by Dr Rodney Holcombe. Dr Holcombe is a Member of the Australian Institute of Geoscientists and is a structural geology consultant working independently under the registered trading name ‘Holcombe Coughlin Oliver’. Dr Holcombe has 46 years of total geological experience, with 10 years as an independent consultant. He has sufficient experience relevant to the style of mineralisation and type of deposit under consideration and to the activity undertaken to qualify as a Competent Person as defined in National Instrument 43 -101 – *Standards of Disclosure for Mineral Projects* ("NI 43-101") of the Canadian Securities Administrators.

## APPENDIX: METHODS

Accurate definition of the lithologies recorded during logging is a requirement for an accurate model, and such accuracy has not always been present in the various generations of Amulsar logs. The development of a lithochemical discriminant in mid-2013 by Nick Oliver provides a major improvement in logging confidence. The discriminant is based on separation of the LV and VC units in Al/Mg:V:Al geochemical space.




The lithochemical discriminant has proved to be a powerful tool at Amulsar, particularly in providing a more reliable data set for RC chips compared to the observational logging, which has proved to be somewhat erratic. While the lithochemical logs have a strong correlation with my own observational core-logging, the correlation is not 100%, with minor differences in the location of some contacts. More problematic is the lack, so far, of a good discriminant for fault intervals, which is critical in this fault-dominated environment. Although the separation of high Fe categories does capture some of the syn-mineralisation oxide-rich fault zones, it doesn't appear to see all of them (perhaps a lower Fe threshold is required). But the vast majority of faults are not Fe-rich and these are not captured by this method (at this stage). Many faults observed in core are defined by noisy oscillation of lithochemical category, but some fault zones, even within an envelope of VC host rock, are lithochemically defined as LV. This corresponds to the observation in core that some faults within VC units contain abundant white clay (LV) gouge. The inference is that some faults, (most likely late faults), have physically transported soft clay fault matrix from adjacent LV bodies.

The 3D modelling (using Micromine) of the present geometry of the argillic altered rocks (LVA) is based on the assumption that the LVA bodies had an originally simple planar geometry. The modelling is not a straightforward process, but is complicated by the fact that each drill string may intersect multiple LVA bodies (creating correlation ambiguities); and the orientation of the LVA sheets within any one zone can vary considerably from its adjacent zone.

It is an iterative (and slow) process. An initial estimate of the most likely correlations that produce approximately parallel bodies of simple geometry is inferred by 3D inspection of several generations of logging. Each contact is modelled through the zone (passing through core contacts) for as long as it maintains simple geometry. Contacts are projected to the surface and adjusted where necessary to accommodate surface data. Where bodies cannot be continued through 3D space, faults are inferred, and the major modelling challenge is to get these faults correctly modelled. Some faults are well defined by the offset of modelled bodies or by consistent logged fault intervals that define planar correlations in 3D space. Others have lesser degrees of confidence and some are entirely inferred. Not all faults have been logged and there are many fault intervals that do not correlate with block bounding faults. The process of defining LVA bodies and faults is repeated for adjacent zones, and common boundaries and faults are iteratively adjusted until the simplest (most planar) solution is reached. Once a volume of rock is defined by its bounding faults, all other isolated LVA intervals within that block are given the same approximate geometry as those used to define the block.

The geometry of each LVA panel is modelled independently within each fault block. The only place where a deliberate correlation between blocks is inferred is where the thickness of a panel is unknown because it has not been fully penetrated by any drilling. In these cases, the thickness of any inferred related panel in the adjacent block is used. However this practice produces an apparently stronger cross-block correlation than actually exists in the data.

The thicknesses inferred for the basal LVA panels are conjectural. In some cases (e.g. southern slide area) minimum thicknesses are known from the surface extent (150-200m), and where it is thought that the model has intersected this same general basal unit, the same thickness is assigned.

The surface expression of panels and faults with low angle dips is a function of the local DTM used to derive the surface intersection. At Amulsar the DTM based on local surveying only extends around the area of high density drilling at the top of the ridge. Beyond that there are various sources of DTM available – all slightly different. The one used here is based on the 1:10000 topographic contours, but has been lowered 7m to best fit the surveyed collars at Orontes. The result is a reasonably good fit to the collars on the western flanks of Amulsar, but is lower than the survey-based DTM at the top of the ridge.

Each modelled panel is ascribed a set of attributes describing the modelling confidence, the number and type of drillholes that intersect and completely pierce the body, and the average thickness of the panel. These attributes are preserved within the Micromine database files (.tdb) supplied but may not translate through to the dxf export files supplied.

**Reference**: 2013: NHS Oliver, "*Amulsar, Armenia: Hydrothermal System appraisal*". Internal report to Lydian Internationals and GeoTeam Armenia.