INTAS PROPOSAL FOR
Open Call 2003 - Research Project

1.1 TITLE:
Island arc magmatism and related mineralization (as exemplified in the Pontide - Southern Caucasian paleo-island arc).

1.1.1 Keyword 1 : Metallogeny
Keyword 2 : Volcanology, Magmatism
Keyword 3 : Pollution & Remediation (including Radioactivity)

1.1.2 Free word 1 : Ore deposits
Free word 2 : Island arc volcanism
Free word 3 : Porphyry intrusives

1.1.3 Intended Start Date: January 2004

1.1.4 Duration: 36 Months

1.2 CONSORTIUM
University of Leicester - United Kingdom
Süleyman Demirel Üniversitesi - Turkey
Caucasian Institute of Mineral Resources - Georgia
Institute of Geology – Georgia

1.3 SUMMARY
The Pontide-Southern Caucasus paleo-island arc is characterized by a varied structure. It hosts a variety of volcanic-associated and porphyry deposits and therefore it is ideal field location to investigate the interplay between metallogeny and volcanism. The relatively deprived area has major potential for future mining, provided that environmental protection can be included in mine design. The main targets of the Project are following: 1. Reconstruction of the volcanic structures of the western and eastern segments of the paleo-island arc; 2. Determination of the paragenetic links between magmatism and mineralization; 3. Compiling 1:50 000 -1:25 000 scale volcanic maps in the districts with volcano-plutonic complexes; 4. Compiling of geologic-genetic and exploration models of volcanogenic and porphyry deposits; 5. Evaluation of the ore potential of volcanic structures and intrusive complexes; 6. Development of environmental models and investigation of polluted areas.

2. TEAM INFORMATION

2.1 Team : Coordination/ Models
2.1.1 Team Description
The University of Leicester has good analytical (XRF, ICP-ES) and GIS facilities. The Black Sea Technical University has excellent facilities for work in the Pontides.
2.1.2 List of publications

2.1.3 Team Leader and address
Title Dr.
Position Lecturer
Sex Male
Date Of Birth 02/05/1951
First Name Charles
Patronic Name
Family Name Moon
Organisation Type Public
Organisation Registration Nr.
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2.1.4 List of Senior Scientists in the team
1) First Name Migrac
Patronic Name
Family Name Akçay
Year Of Birth 1965
Insitute Black sea Technical University, Trabzon, Turkey
2.1.5 Statistics
Number of Team Members involved in this project: 2
Number of Team Members under 35: 0
Number of Team Members who have individually received grants in INTAS projects: 1

2.2 Team: Süleyman Demirel
2.2.1 Team Description
The team is composed of the staff of the Research and Application Center for Geothermal Energy, Groundwater and Mineral Resources (RACGEGMR) and the staff of the Department of the Geological Engineering of the Faculty of Engineering and Architecture, all at the Süleyman Demirel University in Isparta, Turkey. The team leader Nevzat Özgür, Head of RACGEGMR, is professor for Geochemistry and Ore Deposits, and specialist of volcanogenic massive sulfide deposits and fossil geothermal systems. The other team members are as follows: Nuran Sönmez, born 1957, has a Ph.D from 9 Eylül University on Gordes (Manisa) pegmatoids, is a fellow researcher at RACGEGMR. She works in the field of mineralogy and petrography and an experienced fluid inclusion specialist for massive sulfide deposits and epithermal mineralizations. Omer Elitok, born 1968, has a Ph.D from Suleyman Demirel University on geology, mineralogy and petrography of Sarkikaraağaç (Isparta) and environs, is also a fellow researcher at RACGEGMR and a lecturer at the Department of Geological Engineering. He is a mineralogist, and specialist of thin section mineralogy with respect to hydrothermal alteration of massive sulfide deposits. Oya Cengiz, has a Ph.D from Suleyman Demirel University on Barite deposits and their genesis between Sarkikaraağaç? (Isparta) and Doganhisar (Konya), is a lecturer at the Department of Geological Engineering. She is an experienced geochemist for trace element evaluation and interpretation in addition to sulfur isotope geochemistry. Menekse Zerener, has a M.Sc. from Suleyman Demirel University, is working for her Ph.D degree at RACGEGMR and experienced in fluid inclusion study. In accordance with the other work teams, the team two (Geochemistry) will fulfill following tasks: (1) Study of Cu deposits of Kure (Asikoy and Bakibaba) as a Cyprus type ore deposit, Cu deposits of Madenköy, Lahanos and Cerattepe of Kuroko type, Cu deposits of Madneuli (Georgia) and porphyry Cu deposits of Alaverdy (Armenia) with respect to rock and ore geochemistry, hydrothermal alteration, ore microscopy and fluid inclusion measurements, and (2) comparison the deposits with each other and elaboration the reconstruction of the metallogenic evolution of the regions of the East Pontic metallocene and its prolongation in the Lesser Caucasus. The team two is equipped with (i) Atomic absorption spectrometry (Perkin Elmer Analyst 800?), (ii) X-ray diffractometer (PHILLIPS X'Pert PRO), research microscope with image analysis system and fluid inclusion system (Linkam MDS 600).

2.2.2 List of publications

2.2.3 Team Leader and address
Title: Prof.
Position: Head of laboratory
Sex: Male
Date Of Birth: 01/09/1953
First Name: Nevzat
Patronic Name: Özbür
Family Name: Özgür
Organisation Type: Public
Organisation Registration Nr.
Academy / Branch: Süleyman Demirel Üniversitesi
Institute: geology
Department: Research and Application for Geothermal Energy Center
Laboratory: for Geothermal
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2.2.4 List of Senior Scientists in the team
2.2.5 Statistics
Number of Team Members involved in this project: 5
Number of Team Members under 35: 2
Number of Team Members who have individually received grants in INTAS projects: 1

2.3 Team: Ore geology
2.3.1 Team Description
The team consists of researchers of the Caucasian Institute of Mineral Resources (CIMR), Tbilisi State University and Geological Institute As. Sci. Georgia. It is represented by 1. doctor of Science, head of department of metallogeny of CIMR, ore-geologist, specialist of volcanogenic nonferrous and copper-molybdenum-porphyry deposits. He is experienced in compilation of paleo-volcanologic maps; 2. candidate of science head of thermo-baro geochemistry sector, geochemist, mineralogist, specialist of elaboration genetic and thermodynamic models of ore deposits; S. Zurab Laoshvili, 1953 year born, fellow researcher of the geomorphology department of Tbilisi State University, specialist in compiling of
various type maps and creation for them in CIS; 4.Kakhaber Koiava, 1976 year born fellow researcher of Geological Institute As. Sci. Georgia, specialized on volcanogenetic deposits, S.Alexander Razmadze, born 1974 year, senior worker of Geological Institute As. Sci. Georgia specialized in the lithology, stratigraphy and paleontology. According the Project the team undertakes the following works: study of copper-pyrite Cyprus type deposit (Turkey) and epigenetic volcanogenetic and copper-porphyry deposits of Alaverdy mining district (Armenia) and elaboration of genetic and prospecting models in cooperation with other teams. The team proposes to evaluate the ore potential of volcanic and intrusive complexes, in which some of its members have much experience in prognosis of mineralization. The team possesses the following laboratory equipment: 1) Complex apparatus for thermometrical explorations (temperature variance 1000 -4500); 2) Complex apparatus for cryometric explorations (temperature variance -1700 +3000); 3) Vacuum Decrpiptometer with gas-chromatographical prefix (temperature variance of gaseous extraction to 8000); 4) Ultra-violet microscope; 5) Equipment of atomic-absorption analysis; 5) Spectrometer for quantitative analysis DFS-8.

2.3.2 List of publications

2.3.1 Team Leader and address
Title Dr.
Position Academician
Sex Female
Date Of Birth 20/04/1936
First Name Sergo
Patronic Name Amberki
Family Name Kekelia
Organisation Type Public
Academy / Branch Caucasian Institute of Mineral Resources
Department Metallogeny
Laboratory
Street Name Paliashvili
Nr. 85
2.3.4 List of Senior Scientists in the team
1) First Name    Vladimir
Patronic Name     Zinovi
Family Name       laroshevich
Year Of Birth     1948
Institute        Caucasian Institute of Mineral Resources

2.3.5 Statistics
Number of Team Members involved in this project: 5
Number of Team Members under 35: 2
Number of Team Members who have individually received grants in INTAS projects: 1

2.4 Team : Volcanology
2.4.1 Team Description
The team comprises researchers of Geological Institute Ac. Sci.
   1. Professor, Dr.sci., Principal research scientist of the Geological Institute Ac. Sci.
      Georgia specialized in volcanology and ore geology, studied the relation of volcanism
      with hydrothermal alteration and mineralization experienced in surveying of volcanic
      areas;
   2. cand-sci. head of the geochemical sector of Geological Institute Ac. Sci. Georgia, 
      experienced geochemist, studied geochemistry of magmatism and volcanics of various
      geodynamic settings;
   3. Nona Gagnidze (born 1963) fellow researcher of the Geological Institute, specialized
      in volcanology and lithofacies analyses of volcanic sequences;
   5. Nino Sadradze (born 1968) studied Lithology of volcanic-sedimentary orebearing
      sequences.

The team will study mineralized volcanic-structures in various geodynamic settings, such as
oceanic sequences including Cyprus type Asikoy deposit of Kure complex, as well as Kuroko
type and VMS deposits and copper-porphyry deposits of Pontides (Cayeli, Lahanos, 
Cerattepe, Guzelyala). The investigation will be conducted in cooperation with Team 1 and 2.
As well as will be studied epigenetic deposits of Bolnisi mining district (Lesser Caucasus).
The ore potential of the objects will be evaluated and genetic and ore-geologic models of the
deposits will be created. The team possesses the following laboratory equipment: 1)
Equipment for the determination of content of elements by the atomic-absorption
spectrometry method: Perkin-Elmer-305B, Carl-Zeiss FFS-3, Perkin-Elmer-300, PGS-2, 
Perkin-Elmer-355, Hitachi 180-80; 2) Diffractometer X-ray DRON-2; 3) X-ray fluorescence
analyzer KRF-18.
2.4.2 List of publications

2.4.3 Team Leader and address
Title Prof.
Position Head of unit
Sex Female
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Family Name Gugushvili
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2.4.4 List of Senior Scientists in the team
1) First Name Maren
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Family Name Kekelia
Year Of Birth 1933
Institute Institute of geology, Georgian Academy of Sciences
2.4.5 Statistics
Number of Team Members involved in this project: 5
Number of Team Members under 35: 2
Number of Team Members who have individually received grants in INTAS projects: 2

3 OBJECTIVES

3.1 RESEARCH OBJECTIVES
The Alpide paleo-island arc of Pontides and Southern Caucasus is one of the best areas in Eurasia to examine the development of volcanism above a subduction zone and the formation of related mineralisation. Economic volcanic associated massive sulphide deposits (VMS) and epigenetic polymetallic gold-bearing deposits as well as porphyry copper-gold deposits occur in the volcanic sequences.

The objectives of the Project are also economic, aiming at developing realistic geological models to aid exploration for the mining industry in an underdeveloped area. Environmental models are also required at Murgul (Pontides) as well as Madneuli and Shamlug (Lesser Caucasus) to understand the impact of these mines.

The Project proposes detailed investigation (petrological, paleo-volcanological, lithofacies, geochemical and mineralisation) of volcanic structures of the western (Turkey) and the eastern (Georgia, Armenia) sections of the paleo-island arc. The main objectives of the investigation are following:

1. Reconstruction of volcanic structures of both the western and eastern sections of the paleo-arc (sections are distinguished by volcanic sedimentation and ore mineralization).
2. Determination of the paragenetic relation of magmatism with mineralization.
3. Compilation of volcanological maps (1:5 000 - 1:25 000 scales) with VMS deposits (Asikoy and Cayeli Cerattepe - Pontides) and epigenetic base metal deposits (Bolnisi and Alaverdy mining districts of Eesser Caucasus). The areas contain different styles of mineralization.
4. Development of geologic-genetic and exploration models of volcanogenic and porphyry deposits with different styles of mineralization.
5. Evaluation of ore potential of the paleo-island arc volcanic structures.
6. Investigation of environmental impact in the vicinity of producing mines

3.2 Background and Justification

Background

The Pontide-South Caucasian paleo-island arc is an extension of the well-mineralised Carpathian system. The arc can be divided into two sections that are separated by a, later, thick sequence of Neogene volcanics. Structural facies investigations (Yilmaz et al. 2000) determined, that the western (Pontides) and eastern (Lesser Caucasus) sectors differ in the character of their geodynamic development, the nature of the volcanism, as well as in the intensity of volcanic activity and styles of mineralization.

The arc is bounded on the south by continental slivers, of probable Gondwana origin, which possibly also form the basement of the arc (Robinson, 1997). Volcanism in the western part of the arc is dominated by a thick andesite sequence of upper Cretaceous age. Triassic volcanism is in the form of allochthonous areas of basic volcanics (Ustaomer & Robertson, 1993). In contrast, the Lesser Caucasus sector has andesite volcanism of both Bajocian and upper Cretaceous age. Following collision a thick (particularly in W Georgia) section of Eocene volcanics, was generated in a rift environment. Although geophysical data indicate that the E
Pontide section continues to the NE, the exact nature of the correlation with the Lesser Caucasus is in doubt. Yilmaz et al. (2000) proposed a continuation along strike. In contrast, Akdeniz et al. (2000), suggested that a major fault offsets the eastern Pontides and correlated a section around Giumushane with the Bolnisi area.

In contrast to the Carpathian arc, volcanic-associated massive sulphide deposits (VMS) are the dominant type of economic deposit, although vein Au deposits and porphyries have been, and are being, investigated, as well as minor skarns and Mn deposits (Engin et al., 2000; Moon et al., 2001).

VMS deposits occur in a variety of forms: Asikoy (Cyprus style) (Guner, 1980), Kuroko style deposits such as Cayeli (Hobbs, 2000) and Lahanos; gold-rich variants such as Cerattepe (Ciftehan & O'Brien 1998) (Pontides) and Madneuli (Lesser Caucasus); epigenetic styles such as Murgul (Pontides) and Kafan, Alaverdy as well as barite-rich deposits in the Bolnisi district (Lesser Caucasus).

The reason for the generation of the different styles of deposits is not understood in detail but is probably due to differences in water depth, sources of fluids (magmatic or sediment) and fluid pathways. Deposits such as Asikoy, Cayeli and Lahanos probably represent deep-water settings whereas Alaverdy and Madneuli probably formed in shallower water sediments. Fluid inclusion investigations at Madneuli give temperature for copper ores of 370-260°C, for barite-polymetallic ores on 270°-180°C (Kekelia et al., 1993) and deep drilling has cut intrusives underneath the deposit. The Murgul ores currently mined are predominantly of the stockwork type and have been suggested as transitional to porphyry coppers deposits by Ozgiir (1993). Gold occurs in many VMS deposits but deposits such as Cerattepe and Madneuli appear to have epithermal overprints. More conventional vein Au deposits are present both in upper Cretaceous volcanics, such as Altintepe, near Fatsa (Curtis, 2002).

The larger deposits VMS are very significant. At Cayeli, for example, 7.35 Mt of ore had been mined to 2002 and reserves are put at 16.9 Mt of 3.8% Cu, 5.8% Zn, 0.5 g/t Au and 47 g/t Ag (Inmet Mining, 2003). A further resource of 2.9 Mt is inferred. Madneuli and Murgul both contained >70 Mt of ore before mining and Madeuli is currently being mined for gold. The Alaverdy deposits are current under rehabilitation by a private sector group.

Porphyry deposits in the arc occur in a variety of forms and ages. Both Cu-Mo and Cu-Au type have been discovered in the Pontides and Lesser Caucasus (Ratman et al., 1985). Moore et al. (1980) suggested a modal age of ~80 Ma for Pontide granitic magmatism with later phases at 45 and 25 Ma. Exploration in the Artvin area has defined a Au-rich porphyry, temporally associated with the rift stage (Gumushane dated as Eocene (K/Ar: 51-54 Ma, Rockl 1998). In the Lesser Caucasus, porphyries are present at depth in the Bolnisi area and outcrop in the Alverdy district. The younger porphyries in southern Armenia are not related to the Pontide arc and are not the subject of the current project.

The Pontides and Lesser Caucasus are relatively deprived areas of Turkey and Georgia and both areas are experiencing population outflow. Mining represents an opportunity for development. However, many previous mines have been responsible for unacceptable impacts on the environment. Some information (Akçay and Moon, 1999; submitted) provide some information on the Pontides. Acid Mine Drainage is a major result of open pit VMS in Turkey and is also known from Georgia (DAI, 2003). The eventual impact of mining is a combination of the nature of deposits and mining practice. The modern Cayeli operation has relatively little impact because of the disposal of tailings at depth in the Black Sea. Murgul is one of the pollution hot spots within the Black Sea basin as there is no tailings facility and tailings eventually are deposited in the estuary of the Coruh river on the outskirts of the major Georgian city of Batumi.
More detailed analytical data is required from a range of VMS and porphyry deposit to build more detailed environmental models to highlight areas for amelioration and improve the design of future mines.

In summary the following questions need to be solved:

- Character of geodynamic setting, lithofacies and geochemical characteristics of mineralized volcanostructures consist of VMS and epigenetic ores of nonferrous noble metals.
- PT condition scale of formation of various styles of mineralization.
- The sources of mineralization: host rocks or magmatic fluids?
- To generate realistic exploration models for deposits in the Pontide -Southern Caucasian arc.

References


4. SCIENTIFIC / TECHNICAL DESCRIPTION

4.1 Research Programme
The main objective is to fill gaps in the knowledge Pontide-Lesser Caucasian volcanism and magmatic related mineralization. The main method is to remap in detail the mineralized volcanic structures, ore bodies and ore wall altered rocks. The results will be shown on the paleovolcanologic and lithofacies maps and will be used to build geological models of the formation of deposits and hence exploration targets and environmental impact.

The investigation is planned for three years (1.01.2004-31.12.2006).

The first year plan includes detailed investigation of the volcanic structures of the Alaverdy district, including Tekhut, (Armenia) and collection of additional data from the Bolnisi district. This latter study is aimed at compiling a paleo-volcanologic map of this region and detailed investigation of the Madneuli deposit to clarify its genesis. Initially we propose compilation of existing data. Next, background maps of the deposits and a work schedule of the geological investigation will be compiled. After this, field work in Alaverdy and Bolnisi districts for investigation ore deposits is planned. This will involve detailed mapping of mineralized volcanics and associated deposits. The petrographical, geochemical characters and geodynamical conditions of the mineralization will be investigated by laboratory studies of ores and host rocks. After receiving the laboratory data, paleo-volcanological maps of Alaverdy and Bolnisi mining districts and a revised volcanic map of the Madneuli deposit will be compiled. The paleo-volcanological maps will show reconstructed volcanic structure, stages of mineralization and relation with stages of volcanic activity.

The next year similar investigations will be conducted in the districts of Asikoy, Cerattepe, Çayeli and Guzelyala deposits (Turkey). During fieldwork the environmental impact of mining will be established.

In the final year, we will compile the final versions of the paleo-volcanologic maps (1: 50000-1: 25000 scale), maps of the deposits and geological-genetic models. The pathfinders of mineralization for various styles of deposits, chemical, lithological and mineralogical, will be detailed. Models will detail the regional setting of deposits, their relation with volcanic structures, lithofacies affiliation and character of host rocks alteration. The exploration potential of the different areas of the Pontide-Southern Caucasian paleo-island arc system will be evaluated.

Methods: Mineralized volcanic structures will be studied in the field by studying cross section of the volcanic series and analysing ores and host rocks. The deposits will be mapped
and zoning of mineralization and altered host rocks investigated. Maps will be compiled by GIS using ArcView 3.2. Laboratory study includes: microscopic study ores and host rocks; separation of mono-minerallic fractions; determination of trace elements in ores and rocks by XRF, INAA, ICP-MS methods; fluid inclusion analyses (determination of PT conditions of mineralization and chemistry of gas-liquid inclusions); isotope analyses: Sm/Nd, Rb/Sr, Pb; X-ray phase analyses; phase determination by CAMEBAX; determination of ore phases content by XV™ (SCINTAG).

4.2 Project Structure
4.2.1 Task Title: Alaverdy Area: Investigations
Task coordinator: S. Kekelia, belonging to team: Ore geology

Objectives:
The Alaverdy district is representative of the early stage of development of the Pontide-Southern Caucasian paleo-island arc. Volcanic activity occured, mainly, in the shelf zone. Therefore the main targets of the objectives are following:

1. Paleo-volcanological reconstructions in volcanic complexes formed in submarine conditions;
2. Determination of relations between volcanism and mineralizing processes;
3. The study of ore-magmatic systems related to the later stages of development of volcanic structures with VMS mineralization.
4. Compiling of 1:25 000 scale paleo-volcanological map of Alaverdy district completed of Bathonian and Bajocian volcanics.
5. Water and sediment sampling to assess pollution

Methodology:
Initially literature on the Alaverdy district will be collected and compiled; then a draft paleo-volcanological map, will be constructed to determine additional tasks for field work. Investigation on the immediate area 1000 m radius around the limits of Alaverdy copper-zinc-pyrite epigenetic deposit and Tekhut copper-porphyry in the Alaverdy district will be conducted. Lithofacies cross sections will be compiled. At the Shamlug, Alaverdy and Akhtala deposits available drill holes will be logged. A facies analyses reconstructing volcanic structures will be undertaken and content and structures of effusive and explosive facies studied. A special investigation of subvolcanic facies will be conducted, as the copper-pyrite and barite base metal mineralization appear mainly linked with these sub-volcanic bodies.

The Tekhut deposit will be investigated. Pits showing mineralization will be mapped, as well as zones of altered host rocks around the porphyry. Water and sediment samples from drainages will be collected and analysed. The following laboratory investigations are planned: microscopic investigation of ores and rocks (200 thin sections): analyses of major/trace elements by XRF/AAS (30 samples), isotope analyses: Sm/Nd, Rb/Sr, Pb (5 determination). Maps of the results of mapping will be compiled using GIS Arc View-3.2.

Task Input:
The main inputs into the task are information on the deposits available in Tbilisi and Yerevan for 1.1, field support for 1.2 and 1.3 and laboratory access for 1.4. The work will be undertaken by team 3 in collaboration with team 2 with guidance of UK coordinator. The main part of analyses will be conducted in laboratories of Geological Institute of Ac. Sci. of Georgia and Caucasian Institute of Mineral Resources. Determination of trace elements in rocks and ores will be provided by Leicester University, Isotope analyses - in the Institute of
Precambrian Geology and Geochemistry Ac. Sci. of Russia (St-Petersburg). Water and sediment samples will be analysed at Leicester and commercially.

**Result, milestones:**
At the end of 2004 a Report on the work will be presented to INTAS including a 1:25 000 scale paleo-volcanologic map of Alaverdy mining district and explanatory report. This map will be useful for mineralization in the paleo-island arc settings and form the basis of a scientific paper. The environmental data will be released to companies active in the area as well as Armenian government agencies. The risk of failure is excluded, because the team of researchers has all technical means to complete the Task.

4.2.1.1 **Task Title : Literature Search**
Task coordinator: S. Kekelia, belonging to team: Ore geology

**Objectives :**
Literature survey, produce outline maps

**Methodology :**
Literature search, GIS

**Task Input:**
literature, computer access

**Result, milestones :**
maps, report

4.2.1.2 **Task Title : Environmental Sampling**
Task coordinator: C. Moon, belonging to team: Coordination/ Models

**Objectives :**
collect samples of water sediment and soil around contaminated areas

**Methodology :**
Sampling

**Task Input:**
transport, access, maps

**Result, milestones :**
sample results, brief report

4.2.1.3 **Task Title : Mapping (Alverdy)**
Task coordinator: S. Kekelia, belonging to team: Ore geology

**Objectives :**
Describe geology of Area and deposits

**Methodology :**
Mapping, sampling

**Task Input:**
The task is depending on: Literature Search access, transport, field support
4.2.1.4 Task Title: Map Compilation
Task coordinator: S. Kekelia, belonging to team: Ore geology

Objectives:
Compile data, laboratory studies

Methodology:
petrography, geochemistry, mineralogy

Task Input:
The task is depending on: Mapping (Alverdy) laboratory time

Result, milestones:
Report, maps

4.2.2 Task Title: Bolnisi: additional investigations
Task coordinator: V. Gugushvili, belonging to team: Volcanology

Objectives:
As a result of exploration on the INTAS Georgia Project (#1416) a paleo-volcanological map of Bolnisi mining district was compiled and mapping of the Madneuli open pit was conducted. During Cretaceous volcanic activity the shallow sea bottom was uplifted and islands developed, where ignimbrite volcanic eruptions occurred, terminated by cauldron subsidence. The copper-pyrite and barite polymetallic gold-bearing epigenetic deposits are related to these volcanic structures. Mapping of separate parts of Madneuli deposit is planned to clarify the interrelation of different styles of mineralization. The environmental impact of mining has also not been studied in detail. The tasks are:

1. Mapping of the Sakdrisi gold deposit currently under exploration and the David-Garedgi barite-polymetallic deposit;
2. Geochemical analysis of ore-bearing volcanics, and sampling host rocks for determination of PT-condition of mineralization and chemistry of ore forming hydrothermal solutions
3. Sampling of waters, sediments and soils around the Madneuli mine and plant.

Methodology:
The outline of the proposed field area will be evaluated from the abundant existing data on the Bolnisi mining district. During field work mineralized volcanics will be assayed and drill holes and outcrops on the Sakdrisi and David-Garedgi deposits described; 1:1000 scale lithofacies maps will be compiled. The fades character of underlying and overlying beds host will be determined. Distinguishing features of submarine and terrestrial volcanics will be studied. The stages of mineralization on the Madneuli gold-bearing copper-barite-polymetallic deposits will be determined. The content, morphology and relation with mineralization of host rocks, extrusive domes and intrusive bodies will be studied.

In the district, the content of contaminants is enhanced due to acid mine drainage and we propose to sample the soils and waters in detail. 300 thin and polish sections of host rocks and ores will be described. Trace and major elements (20 samples) will be analysed by XRF and ICP-ES methods. As a result of field work and laboratory investigation, a new paleo-
volcanological map of Bolnisi district will be produced with definition of submarine and terrestrial features of volcanic and with determination of the location of ore bodies relative to volcanic structures. Lithofacies maps of the Sakdrisi and David-Garedgi deposits will be compiled.

Task Input:
The main input will be the existing database on the area, some of which is already in digital form, field mapping and sampling. The task will be fulfilled by the researchers from department of volcanology and sector of geochemistry of Geological institute Ac. Sci of Georgia (team 4) in collaboration with Turkish team (Team 2). Determination of elements by methods ICP-ES and XRF will be fulfilled in the Leicester University (UK) and commercially by ICP-MS; isotope investigation at the Precambrian Geology and Geochemistry Institute Ac. Sci of Russian Federation.

Result, milestones:
After completion of the task (end of 2004 year) a report will be presented to INTAS. Report will include: the improved paleo-volcanologic map of Bolnisi district, lithofacies maps of Sakdrisi and David-Garedgi deposits. The data obtained will be used for production of exploration models for Bolnisi style volcanogenic deposits as well as publications
Recommendations for ameliorating the content of toxic metals in the soils and waters of Bolnisi district will be proposed. The chance of non-completion of the task is excluded, as well as teams are comprised of experienced researchers provided with necessary technical means (laboratories).

4.2.3 Task Title : Kïire: volcanism and ore-geology
Task coordinator: S. Kekelia, belonging to team: Ore geology

Objectives:
As is well known, that Kure Complex is an allochthonous structure hosting the copper-pyrite Cyprus style mineralization. The complex is located within the limits of the paleo-island arc but removed far from its source. The following targets are planned:
1. deciphering of structure, study of content of volcanic series and reconstruction of volcanic structures;
2. Determination of the structures, mineral zoning and relation mineralization with host rocks;
3. The compiling of 1:25000 paleo-volcanological map of the district of Asikoy deposit

Methodology:
At the beginning of the year-long study the existing data will be evaluated and outline paleo-volcanologic map compiled; target for the field work will be defined. The field work will be conducted in Kure Complex area (100 km2); the ophiolite complex will be studied entirely, as well as its underlying and overlying beds. The roof and bottom of the allochthonous plates will be studied in especial detail. The type of volcanism (linear or areal?), contents and structures of pillows will be studied, as well as structures of volcanics. The character of inter-pillow sediments (hyaloclastite, siliceous, jasperoids) will be investigated. Usually volcanostructures with Cyprus type of mineralization are located in local depressions on the ocean bottom, filled by volcanic and sediment. The fauna of the latter will be characterized. On the Asikoy open pit the mineralogical mapping of the ore bodies will be undertaken The massive and brecciated ores will be studied as well as underlying siliceous zones that host
disseminated mineralization. The data collected will be used to compile of 1:2500 scale paleovolcanological and 1:2000 scale lithofacies maps. The ore and rocks will be studied microscopically (200 thin and polished sections). XRF and ICP-ES analyes will be undertaken of 20 samples as well as isotopic analyses Sm/Na, Rb/Sr, Pb (5 samples) and X-ray phase analyses (10 determinations). On the paleovolcanological map fades data will be shown, the borders of paleodepression.

**Task Input:**
A large amount of data already exists at MTA and the current mining operation. This will be compiled. The mapping requires access to the area and field support. The task will be undertaken by teams 2 and 3. Laboratory analyses will be conducted in the Geological Institute Ac. Sci. Georgia, as well as in the Caucasian Institute of Mineralization Resources, Geological Survey of Turkey (MTA) and University of Leicester (UK).

**Result, milestones:**
At the end of 2005 a report for INTAS will be presented. To the report will be appended a paleovolcanological map of the area and lithofacies map of Asikoy deposit. The laboratory support and experience of the researchers exclude the risk of failure of this task. The data obtained will be used in volcanology, geochemistry of magmatism and metallogeny and presentations will be made to the Turkish Geological Institute and the mining company.

**4.2.4 Task Title : Eastern Black Sea Deposits**
Task coordinator: N. Ozgur, belonging to team: Suleyman Demirel

**Objectives:**
The region is characterized by development of volcanic suites cut by large intrusive bodies. Deposits associated with the bimodal volcanic series include Kuroko-style VMS deposits (Cayeli) and obviously epigenetic (Murgul) ores, whereas intrusive bodies are associated with copper-porphyry deposits (Guzelyayla). Copper-zinc-pyrite VMS deposit with gold-bearing siliceous sediments occur (Cerattepe), probably on the flanks of volcanic depressions. The main targets of the Task are:
1. Mapping of volcanics in the districts of Qayeli (Madenkoy) and Cerattepe Deposits;
2. Reconstruction of paleo-volcanic structures and correlation of geological conditions of mineralization in the Cayeli and Cerattepe deposits;
3. Mapping of mineralized areas of the deposits;
4. Compilation of 1:25 000-1:50 000 paleo-volcanological maps for Santonian volcanics, as well as lithofacies maps of Cayeli and Cerattepe deposits;
5. Study of ore-magmatic porphyry systems of Pontides exemplified by the Guzelyayla deposit;
6. Sampling of waters and sediments around the Artvin area for environmental signature

**Methodology:**
Initially, literature will be compiled and fieldwork tasks elucidated. During the field work at Cayeli deposit volcanological mapping will be made on a 100 km2 area, and on the 50 km2 around Cerattepe. The content and structure of volcanics will be determined. Fluidity, brecciation, porosity and pillow texture and hydrothermal alteration of dacitic lava flows will be studied, and their correlation with overlying sedimentary rocks and basic volcanics will be investigated. Lithofacies and ore bodies mapping will be mapped. At the porphyry deposit (Guzelyayla) the relation of porphyry intrusions will be studied, as well as zoning of
mineralization, ore content, and host rocks alteration. Soils and waters will be sampled in the Artvin area. The collected matter will be used in map compilation of various scales using Arcview GIS. Microscopic study of rocks and ores (25 sections) is planned, as well as laboratory analyses by XRF methods. Isotopic analyses: Sm/Nd, Rb/Sr, Pb (5 determinations) and X-RF (10 samples) will be accomplished. On the paleo-volcanological maps fades, geochemical data and informations on zoning in mineralization will be reported.

Task Input:
Existing data from the area will be compiled from MTA and universities as well as published information. Access in the area is generally good although vehicles are needed, particularly at Artvin. Summary maps can be compiled from existing regional scale geology as well as LANDSAT imagery, freely available on the internet. Topographic maps are available from Turkish universities. The teams fulfilling the task consist of highly qualified volcanologists of Turkey, Georgia and coordinator from UK. The analyses will be accomplished in the laboratories of the Geological Institute Ac. Sci. of Georgia, MTA Turkey and Leicester University UK.

Result, milestones:
At the end of year a Report on work accomplished will be presented to INTAS. To the Report will be appended paleo-volcanological maps, maps of Çayeli, Cerattepe and Guzelyayla deposits. The region will be evaluated for its volcanogenic and porphyry mineralization potential. Recommendation on the environmental protection will be presented to INTAS, as well as to Turkish institutions. The risk of failure is excluded, because the task will be undertaken by experienced researchers.

4.2.5 Task Title : Modelling
Task coordinator: C. Moon, belonging to team: Coordination/ Models

Objectives:
The task is the final: on the basis of the other tasks genetic and geological models will be compiled. The main targets of the task are following:
1. Developement of genetic models of VMS (Afikoy, Qayeli, Cerattepe, Madneuli, Alaverdy and Shamlug) and porphyry (Guzelyayla, Tekhut) deposits;
2. Detailed comparison with deposits from other areas;
3. Evaluation of exploration potential of Pontide-Southern Caucasian island arc.

Methodology:
The evolution of volcano-plutonism within the limits of the arc will be investigated. Conclusions on the development of the arc will be based on geological, geodynamical, petrological, petrochemical and geochemical data. Geological-genetic models will be compiled according following data: For volcanogenic deposits:
1. paragenetic links of intrusives and extrusive domes;
2. The relation of epigenetic deposits to flanks of volcanodepressions in terrestrial and shallow submarine sedimentation, whereas VMS deposits occur in axial zones of deep sea depressions;
3. The connection of ore content with petrochemical and geochemical peculiarities of host rocks;
4. Isotope-geochemical data of volcanics and sources;
5. Hydrothermal alteration (local and regional);
6. Intrusives as source of metals and heat;
7. Determination of the physical-chemical characteristics of mineralization by gas-fluid inclusions in minerals and rocks;

For copper-porphyry deposits:
1. The spatial relation of mineralization with porphyry intrusive;
2. Isotopic-geochemical criteria of sources of magmas;
3. The evaluation of sources of mineralization and hydrothermal fluids by isotopic relation of sulfur, oxygen and hydrogen;
4. Character of ore wall rock and regional alteration;

Salinity and fluid content and thermodynamic parameters of mineralization on the gas-fluid inclusion data in rocks and minerals;

The exploration models will be compiled on the following criteria, for volcanogenic Deposits

Task Input:
The abundant data on the volcanism, magmatism and mineralization in the paleo-island arc structure, as well as new data obtained during tasks 1-4. Additional laboratory investigations will be conducted in the Caucasian Institute of Mineral Resources (fluid inclusion analysis), in Georgian Technical University (CAMEBAX) and in the Mining Institution Ac. Sci. of Georgia (determination of the mineral phases by diffractometer). The targets will be undertaken with the participation of the all teams.

Result, milestones:
At the end of the year in INTAS will be presented the final Report of the Project, maps, geological-genetic and prospecting models of deposits, data on the potential of the volcanic structures and suggestions for environmental protection on the area of mining and exploration. The models and environmental recommendations will be more widely disseminated in publications and to geological surveys and mining companies. The main success criteria will be following: development of new exploration criteria and their successful application; highlighting of areas that need environmental protection. As the teams are composed of experienced researchers of volcanic regions and possessed all the necessary technical means (laboratory), the risk of failing the task is excluded.

4.3 Project Management

4.3.1 Planning & Task allocation

4.3.1.1 List of Task Titles
1. Alaverdy Area: Investigations
   1.1 Literature Search
   1.2 Environmental Sampling
   1.3 Mapping (Alverdy)
   1.4 Map Compilation
2. Bolnisi: additional investigations
3. Kure: volcanism and ore-geology
4. Eastern Black Sea Deposits
5. Modelling
4.3.1.2 The project will last 36 months with the activities as indicated in the diagram below

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<tr>
<th>Task / SubTasks</th>
<th>Months 1-6</th>
<th>Months 7-12</th>
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4.3.1.3 Team involvement

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4.3.2 Project Management Description

Project Management:
The control on the completion of tasks will be provided by a Council consisting of team leaders guided by the Project Coordinator.
The following scheme is proposed:
2004 year study of the eastern segment of the paleo-island arc structure within the limits of Georgia and Armenia;
2005 will be dedicated to investigation of western segment (Turkey);
2006 all teams will analyse the data collected and results of the laboratory studies of rocks and ores and from these compile maps and models.
At the beginning of the first year (1.01.2004-31.05.2004) on the basis of existing data, outline maps of the Bolnisi mining district (Georgia) and Alaverdy mining district (Armenia), will be compiled. The planning of objectives will be undertaken together with the Coordinator.
Before the beginning of field work (1.06.2004-31.07.2004) there will be a meeting of teams (1, 2) with Coordinator. This will distribute functions between teams and a schedule of working and organise the distribution of the samples in laboratories of country-members of the Project. The field work will be conducted in cooperation with Turkish colleagues (2). The samples collected will be analysed in the laboratories of Georgia, Turkey, UK and commercial companies. The latter teams (2, 3, 4) and Project Coordinator will compile the paleo-volcanological and lithofacies maps of the deposits. At the end of the year research results of Tasks 1 and 2 will be approved by Council, edited by Coordinator and presented as a Report to INTAS.
In the next 2005 year research will be conducted in the Pontides, in the central section including Cyprus-type copper-pyrite deposits and in the east, where in the island arc setting
occur the VMS and epigenetic deposits in volcanic depressions and copper-porphyry, related to uplifted blocks. Initially (01.01.2005- 30.06.2005) Georgian and Turkish teams will evaluate the geological data on the districts and deposits Aşikoy, Cayeli (Madenköy), Cerattepe and Guzelyayla. Preliminary models of paleovolcanological maps will be compiled and created for them using a CIS. Teams 3 and 4 in cooperation with the other teams will conduct field work (01.07.2005 - 31.08.2005). The teams will meet at conference in Isparta (Turkey). After field work (01. 09.2005-31. 12. 2005) samples will be distributed in laboratories of the Georgia, Turkey and UK. After obtaining the results of analyses, compiling maps of the mining districts, updating the maps of deposits, a scheme of evolution of volcano-plutonic complexes of Pontides will be detailed. At the end of the year a Report will be approved by the Council and Coordinator and will be presented to INTAS.

The last year 2006 will be dedicated to analyses of data obtained, to undertake laboratory investigation necessary to compile the genetic models. The final scheme of evolution of magmatism of the Mesozoic arc will be compiled; improved geological maps of deposits, detailed geological-genetic and exploration models produced. The exploration potential of volcanic structures and intrusive bodies will be summarised, as well as environmental impact of mining. At the beginning of the final year a meeting of the Project participants in Tbilisi is proposed, at which will be discussed the methodology of compiling the genetic and prospecting models for volcanogenic and porphyry deposits. Visit of the researchers to European Scientific centres will be discussed. The final Report according to INTAS instruction will be presented to the end of final year. Two colloquia on the magmatism and mineralization in the paleo-island arc systems for the participants of the Project are planned. The first colloquium is proposed in Isparta (Turkey) in 2005 year, the second in Tbilisi - in 2006. The most significant results of research will be presented at international conferences and in peer reviewed journals. The teams will keep in touch by e-mail.

4.4 Project costs
4.4.1 Cost Table

The breakdown of costs of the INTAS contribution (in EURO) is given in the tables below.

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<th>INTAS MEMBER STATE TEAMS</th>
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4.4.2 Justification of Costs

4.4.2.1 Labour costs (only for NIS teams)

Team name: Ore geology

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<th>Number of individual grants</th>
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Team name: Volcanology

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4.4.2.2 Travel and subsistence

Team 1 (Coordination/ Models)

Cost of 4 visits to Georgia by Coordinator and 3 by Senior Scientist
Cost of visit to Tbilisi = 800 € flight + 80 € per day in Tbilisi, 20 € outside 7 days = €1360 X 3 = € 5440, Turkey (14 days) € 500 + € 30/day = €920 total 6360 Turkey -Georgia X 2= €860 X 2 + internal Turkey €810 = 2530 total 8890

Team 2 (Süleyman Demirel)

Travel for field work
Turkey -Georgia X 2- €860 X 2 + internal Turkey €810 = 2530 x3 =7590

Team 3 (Ore geology)

The field works in Alaverdy district (Armenia) supposed in 2004 year. For this rent of car for 2 - months will be necessary. The cost of the rent pear month is 300 € (100 € drivers wage and 200 € petrol's cost) - total 600 €. In the field work will participate 3 specialists. The expenses on 1 specialist are 10 € (5 € accommodation, 5 € food) per day. The expenses of the field team per day 30 €, for 60 days total 1800 €.In 2005 year are planning field works on the Turkish deposits of the Kure complex; Trip of 3 specialists are planning by bus for Ankara and returne to Georgia. The cost of bus 50 € (there and back) for 1 person, for 3 -150 €. The expenses of 1 specialist per day- 20 € (10 - accommodation, 10 food), for the team 60 € per day, for 2 months - 3600 €. The total field working expenses 6150 €. The transport in the field working district will be providing by Turkish side.

Team 4 (Volcanology)

For 2004 by the Project has proosed field works in the Bolnisi district of Georgia. The rent of the car will be necessary for two months. The cost of rent of one car per month will be 300 € (100 € - wage for driver, 200 € cost of petrol) total 600 €. In the field works will participates 3
specialists. The expense for 1 person per day 10 € (5 € - accommodation, 5 € food), total per day for team 30 €, for 60 day - 1800 €. For 2005 year the field works on the ore deposits (Madenkoy, Murgul, Cerattepe, Guzelyayla) of Turkey are planning. 3 specialists will be supposed send to Ankara and return to Georgia by bus. The cost of bus ticket (there and back) 50 € for 1 person, for 3 - 150 €. The expenses of 1 person per day 20 € (10 € - accommodation, 10 € - food), for the team 60 € per day, for two months - 3600 €. The total field working expenses 6150 €. The transport for field working districts will be providing by Turkish side.

4.4.2.3 Consumables
Team 1 (Coordination/ Models)

Team 2 (Süleyman Demirel) Team 3 (Ore geology) Team 4 (Volcanology)

4.4.2.3 Equipment
Team 1 (Coordination/ Models)

Team 2 (Süleyman Demirel) Team 3 (Ore geology) Team 4 (Volcanology)

4.4.2.4 Other Costs
Team 1 (Coordination/ Models)
Other cost include analyses by ICP-ES/MS not possible in Georgia/Turkey €20 per Sample

Team 2 (Süleyman Demirel)
Support sections 50 at 20 analyses: AAS 50 at 20

Team 3 (Ore geology)
The part of laboratory investigation will be provide in other institutions: 1. Isotopes: cost of 1 analysis of Sm/Nd - 100 €, for suppose 5 - 500 €; 1 analysis of Rb/Sr - 80 €, for 5 - 400 €; 1 analysis of Pb - 70 €, for 5 - 350 €; total 1250 €.2. Mineral phases determination by "CAMEBAX" - cost of 1 analysis 15 €, for 5 - 75 €.3. Determination of phase content by the diffractometer XVTN of firm SCJNTAG. The cost of 1 determination - 25 €, for 5 - 125 €. Total in other institutions cost of analyses - 1450 €. For publication some of obtained results are 100 €. Total for other costs - 1550 €.

Team 4 (Volcanology)
The part of laboratory investigation will be provide in other institutions: 1. Isotopes: cost of 1 analysis of Sm/Nd - 100 €, for suppose 5 - 500 €; 1 analysis of Rb/Sr - 80 €, for 5 - 400 €; 1 analysis of Pb - 70 €, for 5 - 350 €; total 1250 €.2. Mineral phases determination by "CAMEBAX" - cost of 1 analysis 15 €, for 5 - 75 €.3. Determination of phase content by the diffractometer XVTN of firm SCJNTAG. The cost of 1 determination - 25 €, for 5 - 125 €. Totals in other institutions cost of analyses - 1450 €. For publication some of obtained results are 100 €. Total for other costs- 1550 €.

4.5 Project innovation potential and dissemination of results
The final scientific products will be: 1. 1:25 000 - 1:50 000 paleovolcanological maps of the mineralized volcano areas: Kiire complex with Cyprus type copper-pyrite ores; VMS Kuroko style deposits of volcano depressions of island arc (Qayeli, Lahanos) and epigenetic goldbearing copper-polymetallic deposits of paleo-island arc (Murgul, Bolnisi), goldbearing
VMS deposits (Cerattepe), epigenetic copper-pyrite and barite polymetallic mineralization of early stage of the paleo-island arc (Alaverdy district). Currently the available maps are old and do not show much detail on volcanology. 2. Geologic-genetic models of VMS sub-types, including epigenetic gold-bearing base-metal-barite deposits. These will be in detail, both paper and digital, and allow the classification of Pontide deposits and generate exploration guides for new deposits and be able with the addition of environmental factors to predict environmental impact. 3. Geologic-genetic models of the copper-porphyry deposits and its correlation with established models: monzonite, diorite with emphasis on gold potential both in paper and digital form. The results will be published and presented on the international conferences as well as to the geological surveys of Turkey (MTA), Georgia and Armenia. The ultimate aim is the generation of new mines that will provide employment in a deprived area at reasonable impact on the environment, i.e. are sustainable.