

**QUARTERLY PROGRESS REPORT
OF THE USGS MISSION,
KINGDOM OF SAUDI ARABIA,
FOR THE THIRD QUARTER
OF THE FISCAL YEAR 1993**



**TECHNICAL REPORT
USGS QR-93-3**

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**MINISTRY OF PETROLEUM AND MINERAL RESOURCES
DIRECTORATE GENERAL OF MINERAL RESOURCES
JIDDAH, KINGDOM OF SAUDI ARABIA
1414 AH 1993 AD**

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**July 1 - September 30, 1993
(12 Muharram - 14 R. Thani 1414)**

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USGS QR-93-3
(IR 873)**

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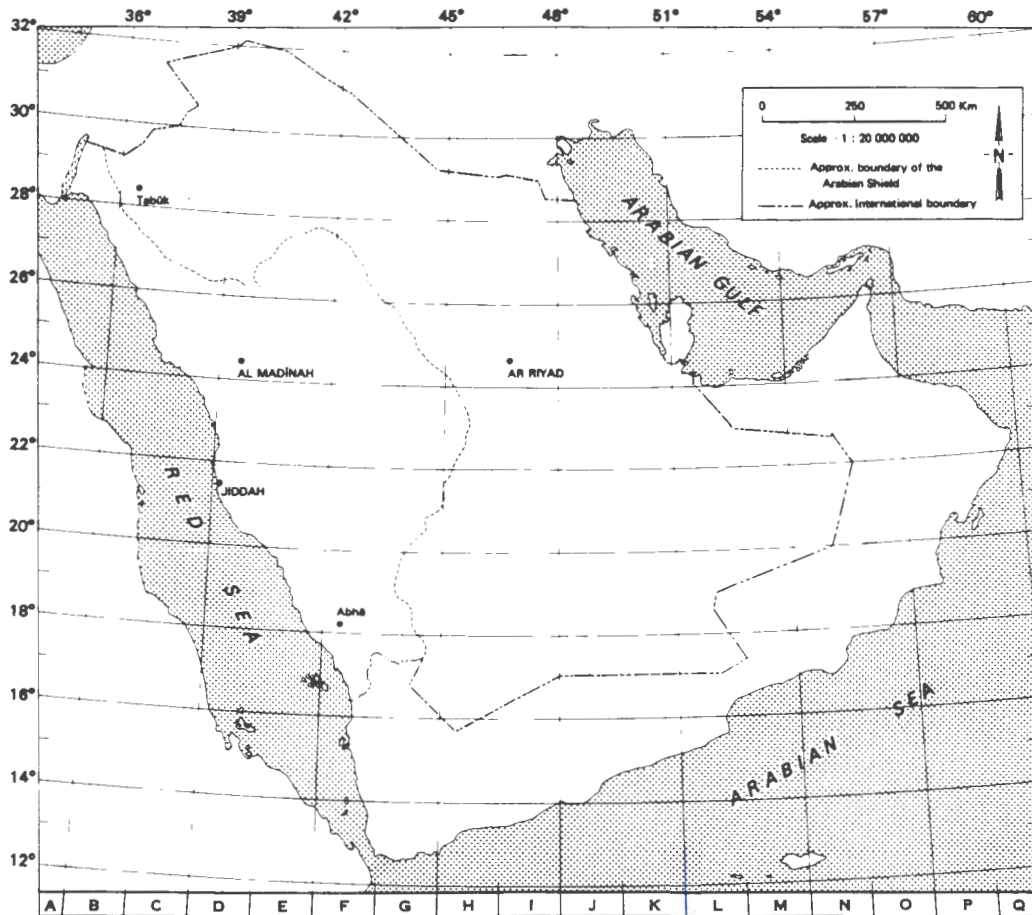
An Interagency Report prepared by the
U.S. Geological Survey, Saudi Arabian Mission
for the
Ministry of Petroleum and Mineral Resources
Kingdom of Saudi Arabia

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Index map of the Arabian Peninsula

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EXECUTIVE SUMMARY

The USGS Third Quarterly report gives details on all USGS Mission operations at headquarters, in the field, and in the various laboratories for the period from July 1, 1993 to September 30, 1993 (12 Muharram 1414 to 14 R. Thani, 1414).

Field activities related to regional mapping occurred in the northern part of the Kingdom in the Al Jawf, At Tubayq and Ash Shuwayhitiyah 1:250,000 quadrangles. Preparation of two 1:250,000 quadrangles for publication (Ash Shuwayhitiyah and Turayf-An Nabk) is progressing. The general assessment of geohazards was completed. Data were catalogued for more than 300 earthquakes known to have occurred in Saudi Arabia and adjacent countries. The 8 seismic stations at Al Madinah continued to monitor events in the immediate area. Radon studies have been initiated, hazardous waste dumping is being monitored, and an oral report on solid-waste land fill, which was done at the request of the Jeddah Municipality, was given to city officials. Gold exploration reports for the Hamdah and Bi'r Hamadan mineral belts were completed. Work is in progress for the As Siham, An Najadi, Al Wajh, and Murayjib-Umm Hafra mineral belts. Reports on gold prospects at An Najadi and Meshahed were completed. Work at Wadi Sha'bah NE and E gold prospects continue. In phosphate, the report on regional assessment for the entire Al Jalamid area was completed and is in review.

1. GEOLOGIC MAPPING

Preparation of two quadrangles, Ash Shuwayhitiyah (30D) and Thaniyat (31C)-An Nabk (31B) prior to submission for publication continued under the supervision of Robert Fraser (USGS-OSP Reston). Detailed mapping, structural and stratigraphic studies on Tertiary sedimentary rocks were carried out in the Al Jawf, At Tubayq, and Ash Shuwayhitiyah quads. Chemical analyses of 483 samples from stratigraphic holes drilled in May were completed and studied. Results will allow the placement of the contact between the Aruma and Jalamid formations in the Hazm al Jalamid (formerly Al Hamad) quadrangle, thereby giving much needed stratigraphic and structural information on the extent of phosphate south of the Al Jalamid deposit.

2. GEOLOGIC HAZARDS

A general assessment of geohazards and a 1:4,000,000-scale geohazards map are in revision stages, both products are planned for release in the fourth quarter.

An earthquake catalog has been compiled containing more than 300 entries for Saudi Arabia and adjacent countries. Eight seismic stations continue to monitor the Al Madinah area for volcano-seismic activity; no major events occurred in the third quarter.

The aeroradiometric anomaly map of the Arabian Shield has been digitized in an effort to correlate the high uranium occurrences with high population centers. Soil-gas monitoring equipment has been ordered to quantify the amount of radioactive radon present at selected soil

locales known to have high radioactivity from the aforementioned map. Prolonged breathing of high levels of radon are known to contribute to lung cancer and leukemia. Monitoring of sewage waste dumping in east Jeddah continued. Dumping from tanker trucks has increased many-fold at the approved disposal site. However, breaching of retaining berms has resulted in downstream flooding by effluent. The water table, now locally contaminated, has risen to form lakes in areas east of the Saudi Aramco Tank Farm. An oral report on the results of the solid-waste landfill study for the City of Jeddah, done at the request of the Municipality and authorized by DGMR, has been given; this will be followed-up by a written report, in English and Arabic, to be transmitted during the fourth quarter. A site visit on September 25, 1993, to a hot spring at Ghumayqah, about 27 km east of Al Lith, showed temperatures at 89-90°C, normal pH (7.5) and highly saline chemical content.

3. MINERAL EXPLORATION

Regional reconnaissance studies: Reconnaissance work was carried out at Al Qubbah. Reports are in progress for Lugatah and Mokhyat gold prospects. Studies continued on the Tertiary weathering surface in western Saudi Arabia. Weathering profiles will be compared for areas north and south of the Ad Damm fault. Two of the six planned 1:500,000 scale maps on the basement rocks of the Arabian Shield are finished and will be readied for publication and distribution early in the fourth quarter.

Mineral belt studies: The Hamdah mineral belt report is in review, the Bi'r Hamadan report has been transmitted. An Najadi mineral belt report is being written. Reports on individual gold prospects within the Najadi mineral, Agob, Agob north, Wuday and Wuday west are also in progress. The geologic map and the wadi geochemical sediments study are being compiled for the Al Wajh mineral belt. At Murayjib-Umm Hafra Region 21 gravity profiles and a map showing depth to bedrock were completed. Interesting deeply buried ravines were indicated which will need to be examined as possible paleo-gold trap structures.

Gold prospects: The An Najadi gold prospects report was completed and entered peer review. A geophysical section containing gravity, magnetic, and radiometric data is included. At Meshaheed geologic mapping, sampling, chemical analyses, and compilation of data were completed. Report writing started for Meshaheed Pluton Southeast and Meshaheed Pluton West/Southwest. Data compilation and report writing are in progress for Wadi Sha'bah Northeast and Wadi Sha'bah East prospects. Four areas are recommended for drilling at Wadi Sha'bah East.

4. MINING DEVELOPMENT

The regional assessment report for the entire Al Jalamid area was completed and reserves were calculated at 400 million tons (MT). This includes the 213 MT for the Feasibility Study Area. An additional 363 MT containing phosphate with high MgO content was calculated to be present in nearby areas. A. Farasani will participate in promotional seminars on phosphate in Toronto and Vancouver, Canada in November.

At the Ghurayyah Rare Metal Deposit variograms of existing analytical data were compiled from nearly 2600 surface samples. Results indicate extreme variability and cast doubts on the reliability of the estimated rare metals content of the deposit. Further attempts will be made to characterize the natural variability of the granite stock and drill core will be relogged using a spectrometer for equivalent U, K, and Th and resampled for chemical content.

5. SUPPORT ACTIVITIES

Chemical analysis laboratory: The laboratory crushed 2,590 samples and completed analyses on 2,912 samples resulting in 10,209 determinations for the quarter. No samples remain on backlog for analyses. A new Induction Coupled Plasma (ICP) Mass Spectrometer instrument arrived in September. Its capabilities will augment the DGMR/USGS Chemical Laboratory greatly in being able to determine isotopes of trace-elements in the low parts per trillion range. A. Davies, the company expert on the machine, will arrive in early October for installation and final checking.

Geophysics section: Geophysics continued its busy schedule for BRGM, DGMR, and USGS projects with field efforts at Al Mohseniyah, Rabathan, Yanbu and Jabal Shayban. Plans were made for work in the Al Jawf area early in the fourth quarter. An inventory of all geophysical data and maps in the geophysics section was initiated to facilitate future search and recovery of data filed in the geophysics archives. A large magnetic dataset consisting of USGS and ARAMCO information was assembled and organized by Dr. Nimr Arab. He is now processing data from 28,000 gravity stations obtained from Saudi Aramco covering the eastern Red Sea coastal margin.

Petrologic and mineralogic laboratory: The laboratory processed 973 samples for the third quarter, serving DGMR, BRGM and USGS. The laboratory recently expanded its capabilities by providing formal space for its Knelson concentrators, gold hounds, and Wilfley table in an area previously assigned to drum storage. A spare parts room was converted to a "clean room" where optical microscopes were installed for the examination of thin sections. Exhaust hoods were installed in the crushing and grinding area thereby providing a healthier environment for the work.

Remote sensing: Expansion of the remote sensing center has begun. A VAX 4200 computer system now allows processing of digital imagery. New minicomputers and important display capabilities allows our remote sensing center to be one of the best in the world. Experts from the USGS Flagstaff (Arizona) office (who do contract analysis work for NASA) installed and tested fully all systems now in place in the center. Training by Flagstaff personnel on the software systems is ongoing. Dr. Phil Davis, Senior Scientist and Chief of the USGS Branch of Astrogeology in Flagstaff provided training on theory and use of image processing algorithms. Geophysical Environmental Research (GER) Company out of New York were awarded the contract to fly selected areas of the Arabian Shield and a coastal corridor between Jeddah and Yanbu to obtain 63 channel scanner imagery. GER had severe problems with its scanner equipment and software but thanks to the tremendous efforts of Dr. Davis, Dr. Wynn and USGS and GER staff and the cooperation of DGMR, ARGAS and Special Flights staff correction of the problems were given the highest priority and the system eventually became operational. Valuable flying time, however, was lost during this repair period because of the progressive shortening of sun-time per day and the onset of cloudier weather. This has been partially mitigated by a planned extension of contract by

GER into late November, and further mitigated by the fact that local employees received additional training during the down time.

Photographic services: The photographic laboratory processed 86 requisitions representing 1,159 reproductions during the third quarter. Equipment is in need of repair at the laboratory.

Computer services: An Najadi data was input, proofread and edited for overburden, trench and drill hole data during the third quarter. An estimate for gold content for overburden and bedrock was completed. Various statistical data, histograms, plots and cross sections were generated by TECHBASE for the An Najadi report. Wadi Sha'bah data were entered into Lotus 123. Earthquake data were entered in TECHBASE for the Geohazards Section and location plots were generated.

Library and bibliographic services: Routine library activities continued. Journal subscription orders were placed early to avoid delayed issues in 1994. The bibliography of DGMR, USGS, BRGM and Riofinex products was revised to include the most recent 3 years and will now cover the period from 1985 to 1993. This publication will be released as a DGMR Bulletin.

Technical Reports Unit: Editing, map drafting, and printing was completed and six reports transmitted: the Second Quarterly Report; two mineral belt reports -- Jabal Riah and Bi'r Hamadan; a wadi-sediment geochemistry report on the Hamdah-Jabal Riah gold district; a report on magnetic anomalies and basement structure in central Arabia; and a report on geochronologic data for Precambrian rocks of northeast Africa and Arabia.

Publications: Five DGMR reports were published and distributed. The cartographic section processed 20 drafting and typesetting jobs; the print shop processed 66 requests representing 45,334 items printed. The distribution section sent out 883 copies of reports and maps.

Land transportation and Field services: These sections supported USGS field camps at Jabal Sayid, Al Jalamid, Al Madinah, Meshahed, Murayjib, Turayf and a short-term camp at Aqiq, providing field services, repairs, maintenance, supplies, and logistics. Special needs were generated by the camp at Jabal Sayid where the GER remote-sensing operation was in progress. Here three diesel tankers were required for refueling Special Flights aircraft and two water trucks were necessary for camp needs.

معمل التصوير :

قام المعمل بمعالجة ٨٦ طلبا أنتجت ١١٥٩ صورة خلال الربع • وتحتاج الأجهزة في المعمل للإصلاح •

خدمات الحاسب الآلي :

تم الدخال ومراجعة وتنقيح البيانات الخاصة بصخر الغطاء وحفرالخدائق وأعمال الحفر في منطقة النجادي • واكتمل عمل تقديرات محتوى الذهب في صخر الغطاء وصخر القاعدة • كما تم انتاج العديد من البيانات الإحصائية والرسومات البيانية والمخططات والمقاطع لتقرير النجادي باستخدام برنامج (تكبير) • وأدخلت البيانات الخاصة بمكن وادي الشعبة على برنامج (لوتس ١٢٣) • كما أدخلت البيانات الخاصة بالزلازل على برنامج (تكبير) وتم انتاج مخططات للمواقع وذلك لصالح قسم المخاطر الجيولوجية •

مركز المعلومات والوثائق :

استمرت الأنشطة الروتينية بالمكتبة • وأرسلت طلبات الاشتراكات في المجلات العلمية في وقت مبكر لتفادي تأخير وصولها خلال عام ١٩٩٤م • تمت مراجعة الببلوغرافيا الخاصة بمطبوعات المديرية والبعثات الأمريكية والفرنسية وريوفنيكي سابقا لتشمل السنوات الثلاثة الأخيرة وهي الآن تغطي الفترة من ١٩٨٥م إلى ١٩٩٣م وسوف يتم نشرها من قبل المديرية في شكل نشرة دورية •

وحدة التقارير الفنية :

اكتملت أعمال التنقيح ورسم الخرائط والطباعة لستة تقارير وتم رفعها للمديرية وهي كالتالي : التقرير ربع السنوي الثاني - تقريرين عن أحزمة التمدن : جبل رية وبتو حمدان - تقرير عن الاستكشاف الجيوكيميائي لرسوبيات الوديان في منطقة ذهب حمضة - جبل رية - تقرير عن الأنماط المغناطيسية وتركيب الأساس في المنطقة الوسطى - تقرير عن بيانات التقييم الجيولوجي لصخور ما قبل الكمبري في شمال شرق أفريقيا والجزيرة العربية .

التحرير الفني :

تم نشر وتوزيع خمسة تقارير للمديرية . وقام قسم الرسم الفني بانجاز ٢٠ مهمة للرسم الفني وصف الحروف . كما قامت المطبعة بتنفيذ ٦٦ طلبا تمثل ٤٥٣٣٤ مادة مطبوعة . وقام قسم التوزيع بتوزيع ٨٨٣ نسخة من التقارير والخرائط .

المواصلات وخدمات الحقول :

يقوم القسم بتقديم المساندة لمخيمات الحقول التابعة للبعثة في جبل صايد والجلاميد والمدينة المنورة ومشاهيد ومريجي وطرير ومخيم مؤقت في العقيق وذلك بتأمين خدمات الحقول والقيام بأعمال الإصلاح والصيانة والتجهيزات والدمج اللوجستي . كما تمت تلبية الاحتياجات الخاصة في مخيم جبل صايد لمساندة أعمال الاستشعار من بعد التي تنفذها شركة (جي اي آر) بتأمين ثلاثة ناقلات لتوفير المحروقات لطائرات الطيران الخاص اضافة الى ناقلتي ماء لتلبية احتياجات العاملين في المخيم .

قسم الجيوفيزياء :

استمر القسم في تنفيذ جدول العمل الخاص بمشاريع المديرية والبعثتين الجيولوجيتين الفرنسية والأمريكية في مناطق المحسنية وربشان وينبع وجبل شيبان • وأعدت الخطط الخاصة بالعمل في منطقة الجوف في أوائل الربع الأخير • بدأ القيام بحصر كافة البيانات والخرائط في القسم وذلك لتسهيل البحث واستعادة البيانات المودعة في أرشيف القسم مستقبلا • وقام الدكتور / نمر عرب بتجميع وترتيب مجموعة بيانات مغناطيسية كبيرة من المعلومات المتوفرة لدى البعثة الأمريكية وأرامكو ويقوم حاليا بمعالجة البيانات من ٢٨,٠٠٠ محطة جاذبية تم الحصول عليها من أرامكو تغطي السهل الساحلي الشرقي للبحر الأحمر •

معمل حراسة الصخور والمعادن :

قام المعمل خلال الربع بمعالجة ٩٧٣ عينة لصالح المديرية والبعثتين الفرنسية والأمريكية • ووسع القسم من قدراته بتخصيم مساحة لأجهزة التركيز نلسون وأجهزة الفصل قولدهاوند وطاولة ولغلي وذلك في المكان الذي كان مخصصا من قبل كمستودع • وحولت غرفة قطع التيار الى غرفة نظيفة تضم المجاهر البصرية المستخدمة في فحص الشرائح البصرية • كما تم تركيب عوادم للأبخرة في أقسام التكسير والطنن لتأمين بيئة عمل صحية •

الاستشعار عن بعد :

بدأ العمل في توسيع مركز الاستشعار عن بعد ويقوم جهاز الحاسب الآلي فاكس ٤٢٠٠ بمعالجة الصور الفضائية الرقمية • وبفضل وجود أجهزة الحاسب الآلي الدقيقة الجديدة ومقدرات العرض المرئي الضرورية فقد أصبح هذا المركز من أفضل المراكز في العالم • وقام خبراء من مكتب مصلحة المساحة الجيولوجية الأمريكية في فلاجستاف بولاية أريزونا (الذين يقومون بأعمال تحليل تعاقدية لوكالة الفضاء الأمريكية) بتركيب واختبار كافة الأنظمة الموجودة حاليا في المركز ويستمر تدريب منسوبي المركز على برامج الحاسب الآلي وذلك بواسطة الخبراء من فلاجستاف وقدم الدكتور / فيل ديفيز كبير العلماء ورئيس فرع الجيولوجيا الفلكية التابع لمصلحة المساحة الجيولوجية الأمريكية في فلاجستاف التدريب النظري والعملي على استخدام برامج معالجة الصور الفضائية •

وتم ابرام عقد للطيران فوق مناطق مختارة من الدرع العربي والشريط الساحلي بين جدة وينبع للحصول على ٦٣ صورة فضائية مع شركة جيوفيزكال انفيدومنتال رسيرش (جي اي آر) في نيويورك وقد جابهت الشركة صعوبات جمة تتعلق بجهاز المسح البصري والبرامج الخاصة به بيد أنه تم التغلب على تلك الصعوبات وذلك بفضل الجهود المشتركة التي بذلها كل من دكتور ديفيز ودكتور وين ومنسوبي البعثة والشركة المذكورة وتعاون المسؤولين في كل من المديرية وأركاس والطيران الخاص • وخلال الفترة التي استغرقتها عملية الإصلاح فقدنا وقتا ثميننا للطيران نظرا لأضرار قصر وقت النهار ودخول جو غائم • وتم التخفيف من آثار ذلك جزئيا عن طريق التوسعة المقررة للمعدن من قبل الشركة بحيث يمتد حتى أواخر شهر نوفمبر كما كان من الآثار الايجابية لذلك أن العاملين المحليين تلقوا تدريبات اضافية خلال فترة توقف الطيران •

ويتم في الوقت الراهن تجميع الخريطة الجيولوجية ودراسة الاستكشافات الجيوكيميائية لرسوبيات الوديان لحزام تمعدن الوجه • وفي منطقة مريجيبي أم حفرة اكتمل اعداد ٢١ قطاعا جاذبيا وخريطة توضح العمق حتى صخر القاعدة حيث ظهرت أودية صغيرة مطمورة قد تتطلب القيام بدراستها إذ أنها قد تشكل تراكيبي محتملة كمصيدة قديمة للذهب •

مكامن الذهب :

اكتمل تقرير مكامن ذهب النجادي وهو الآن قيد المراجعة الثانية • ويشتمل التقرير على فصل عن الجيوفيزياء يحتوي على بيانات جاذبية ومغناطيسية واشعاعية • كما اكتملت أعمال رسم الخرائط الجيولوجية وجمع العينات والتحليل الكيمائية وتجميع البيانات في مشاهيد • وقد بدأ العمل في كتابة التقارير الخاصة بمناطق بلوتون مشاهيد جنوب شرق وبلوتون مشاهيد غرب/جنوب غرب • كما يستمر تجميع البيانات وتحرير التقارير الخاصة بمكامن وادي الشعبة شمال شرق ووادي الشعبة شرق • وتمت التوصية بالقيام بأعمال الحفر في أربعة مناطق في وادي الشعبة شرق •

٤ - تطوير المناجم :

انتهى التقرير الخاص بالتقويم الاقليمي لمنطقة الجلاميد حيث قدرت الاحتياطات ب ٤٠٠ مليون طن تشمل ٢١٣ مليون طن في منطقة دراسة الجدوى الاقتصادية • كما تم حساب كمية اضافية في المناطق المجاورة تبلغ ٣٦٣ مليون طن تحتوي على فوسفات يشوبه محتوى مرتفع من أكسيد المافنسيوم • وسوف يشارك أنور الفرسان في ندوات ترويجية من الفوسفات تعقد في مدينتي تورنتو وفانكوفر بكندا خلال شهر نوفمبر •

في راسب المعادن النادرة في القرية تم تجميع رسومات بيانية للبيانات التحليلية المتوفرة حاليا وذلك لما يقارب ٢٦٠٠ عينة سطحية • وتظهر النتائج تباينا شديدا وتلقى بالشكوك حول دقة تقدير محتوى الراسب من المعادن النادرة وستجرى محاولات اضافية لتحديد خصائص التباين الطبيعي لصخر الجرانيت ، اضافة الى القيام باعادة دراسة العينات اللبية باستخدام جهاز قياس الطيف لتحديد كميات اليورانيوم والبوتاسيوم والثوريوم المكافئة كما سيعاد جمع العينات لتحديد محتواها الكيمائي •

٥ - الأنشطة المسانحة :

المعمل الكيمائي :

قام المعمل الكيمائي بطحن ٢٥٩٠ عينة واكتمل تحليل ٢٩١٢ عينة نتج عنها تحديد ١٠٢٠٩ عنصر خلال الربع ، وبذلك لا تبقى أية عينات قيد التحليل • وفي شهر سبتمبر تم استلام جهاز جديد للبلارما مما سيرفع من طاقة (أو قدرة) المعمل بصورة كبيرة بحيث يتمكن من تحديد نواتج العناصر النخرة حتى الأجزاء الدقيقة من التريليون • وسوف يصل خبر الشركة إليه • ديفيز في أوائل أكتوبر للقيام بالتركيب والفحص النهائي •

٢ - المخاطر الجيولوجية :

تجرى حاليا مراجعة تقرير حول التقييم العام للمخاطر الجيولوجية وأيضا خريطة للمخاطر الجيولوجية بمقياس رسم ١ : ٤,٠٠٠,٠٠٠ ومن المؤمل نشرها خلال الربع الأخير .

تم تجميع بيان للزلازل يحتوي على أكثر من ٢٠٠ مدخلا للمملكة العربية السعودية والبلدان المجاورة كما تستمر مراقبة النشاط البركاني والزلازمي في المنطقة المحيطة بالمدينة المنورة عن طريق المحطات الزلزالية الثمان . ولم يسجل وقوع أية أحداث رئيسية خلال الربع الثالث . وتم ترقيم خريطة الأنماط الجوية الإشعاعية للدرع العربي بغية مقارنة التواجدات العالية لليورانيوم مع المراكز العمرانية المكثفة . كما أننا بصدد تأمين أجهزة مراقبة الغازات في التربة لاستخدامها في قياس كميات غاز الرادون المشع في مواقع مختارة معروفة بارتفاع الإشعاعية وذلك من واقع الخريطة آنفة الذكر . ومن المعروف أن التعرض لاستنشاق كميات عالية من غاز الرادون لفترات طويلة يساعد على الإصابة بسرطان الرئة وسرطان الدم . واستمرت مراقبة كيفية التخلص من مياه الصرف الصحي في شرق مدينة جدة . وقد تزايد معدل تصريف ناقلات المياه (الوايتات) الوايتات في الموقع المخصص للتصريف بيد أن عدم مراعاة التصريف في البرك المخصصة لذلك أدت إلى فيضان مياه الصرف الصحي داخل مجرى الوادي . وارتفع منسوب الماء الباطني الملوث مكونا مستنقعات في المناطق الواقعة الى الشرق من خزانات شركة أرامكو السعودية . ورفع تقرير شفهي عن دراسة مدفن النفايات الصلبة التابع لأمانة مدينة جدة والتي تمت بناءا على طلب من المسؤولين في الأمانة وبعد موافقة المديرية على ذلك . وسيلي ذلك تقديم تقرير خطي باللغتين العربية والانجليزية خلال الربع الأخير . وبتاريخ ٢٥ سبتمبر ١٩٩٣م ، تم القيام بزيارة لموقع ينبوع للماء الحار في قرية غميقة على بعد حوالي ٢٧ كيلومترا شرق الليث وكانت نتائج القياسات التي تمت كالتالي : درجة حرارة المياه ما بين ٨٩ الى ٩٠ درجة مئوية والرقم الهيدروجيني العادي ٧,٥ والمحتوى الكيميائي للمياه شديد الملوحة .

٣ - الاستكشاف المعدني :

دراسات الاستطلاع الاقليمي : أجرت أعمال الاستطلاع في مكن القبة للذهب ويجري اعداد التقارير الخاصة بمكني الذهب في لقطه ومخيظ . وتستمر دراسة السطح المتجوى من العصر الثلاثي في المنطقة الغربية من المملكة حيث تجرى مقارنة قطاعات متجوية من المناطق الواقعة الى الشمال والجنوب من صدع الدم . وقد أنجزت خريطتان بمقياس رسم ١ : ٥٠٠,٠٠٠ من بين الخرائط الست المقرر اعدادها لصخور الأساس في الدرع العربي على أن يجري نشرهما وتوزيعهما في أوائل الربع الأخير .

حراسات أحزمة التمعن :

تجرى مراجعة تقرير حزام تمعدن حمضة كما تم رفع تقرير بئر حمدان ويستمر العمل في تحرير تقرير حزام تمعدن النجادي . ويستمر العمل في اعداد التقارير الخاصة بمكامن الذهب في حزام تمعدن النجادي وهي عقوب وعقوب شمال وودي وودي غرب .

خلاصة

يتضمن التقرير ربع السنوي الثالث للبعثة الجيولوجية الأمريكية تفاصيل عن كافة العمليات التي قامت البعثة بتنفيذها في المكتب الرئيسي وفي الحقول والمعامل العديدة التابعة لها وذلك خلال الفترة من ١٢ محرم الى ١٤ ربيع الآخر ١٤١٤ الموافق ١ يوليو الى ٣٠ سبتمبر ١٩٩٣ م .

تركزت الأنشطة المحلية في القيام برسم الخرائط الإقليمية في الجزء الشمالي من المملكة في مربعات الجوف والطبيق والشويحية بمقياس رسم ١ : ٢٥٠,٠٠٠ . ومايزال العمل يجري لأعداد خريطين للنشر بمقياس رسم ١:٢٥٠,٠٠٠ لمربع الشويحية وطريق النيك . واکتملت أعمال التقويم العام للمخاطر الجيولوجية ، حيث تمت فهرسة البيانات المتعلقة بما يزيد عن ٣٠٠ زلزالاً كانت قد وقعت في المملكة والبلدان المجاورة ، واستمرت مراقبة النشاط السيزمي في المنطقة المحيطة بالمدينة المنورة عن طريق المحطات السيزمية الثمان . كما بدأت دراسات غاز الرادون وتجرى مراقبة التخلص من النفايات الضارة ، كما تم تزويد المسؤولين في أمانة مدينة جدة بتقرير شفهي حول مدفن النفايات الصلبة التابع للأمانة وذلك بناءً على طلب منهم . وقد اكتمل اعداد التقارير الخاصة باستكشاف الذهب في أحزمة التمعدن في حمضة وبتغر حمدان ، ويجري العمل الآن في أحزمة التمعدن في السهام والنجادي والوجه ومريجيح أم حفرة . وتم اعداد التقارير الخاصة بمكمني الذهب في النجادي ومشاهيد . ويستمر العمل في مكمني الذهب في وادي الشعبة شرق وشمال شرق . وبالنسبة للفوسفات فقد اكتمل التقرير الخام بالتقويم الاقليمي لكل منطقة الجلاميد بكاملها وهو الآن قيد المراجعة .

١ - رسم الخرائط الجيولوجية :

استمر العمل في تجميع الخرائط لمربعين هما : الشويحية (٣٠ادي) وشنيحات (٣١سي) - النيك (١٣بي) توطئة لنشرهما وذلك تحت اشراف روبرت فريزر من مكتب مصلحة المساحة الجيولوجية الأمريكية في رستون . وتم القيام برسم الخرائط التفصيلية والدراسات التركيبية ودراسة التتابع الطبقي للخور الرسوبية من العصر الثلاثي في مربعات الجوف والطبيق والشويحية . واکتملت التحاليل الكيميائية التي أجريت على ٤٨٣ عينة من حفر التتابع الطبقي التي حفرت في شهر مايو وبفضل نتائجها أصبح بالإمكان تحديد خط التماس بين متكوني عرمة والجلاميد في مربع حزم الجلاميد (الحمد سابقاً) مما يؤمن الحصول على مزيد من المعلومات الطبقيّة والتركيبية المطلوبة لمعرفة نطاق امتداد الفوسفات جنوب راسب الجلاميد .

QUARTERLY PROGRESS REPORT OF THE USGS MISSION, KINGDOM OF SAUDI ARABIA, FOR THE THIRD QUARTER OF THE FISCAL YEAR 1993

**JULY 1 - SEPTEMBER 30, 1993
(12 MUHARRAM - 14 R. THANI 1414)**

INTRODUCTION

This report records the work of the USGS Mission in Saudi Arabia during the third quarter of the Fiscal Year 1993. The work has been done in accordance with the Tenth Extension to the Work Agreement between the Ministry of Petroleum and Mineral Resources and the U.S. Geological Survey (USGS). The Tenth Extension Agreement is for five years and covers the period from January 1, 1990 to December 31, 1994 (4 J. Thani, 1410 to 29 Rajab, 1415).

Staff assigned to the USGS Mission during the quarter are listed in Appendix 1 of this report. Locations of USGS projects are shown on figure 1.

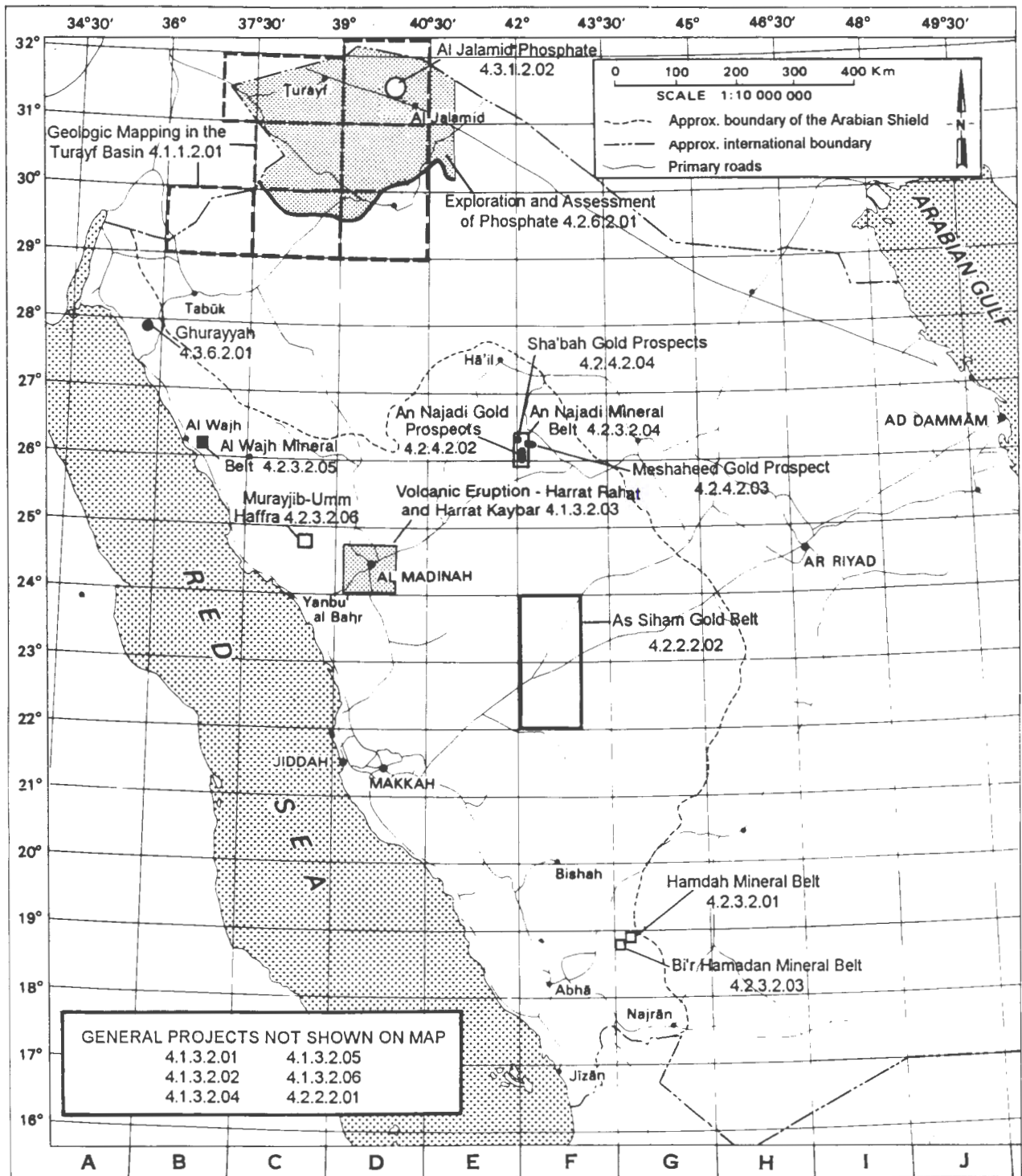


Figure 1. Locations of USGS projects. Numbers refer to project listings in the DGMR work program.

1. MANAGEMENT AND ADMINISTRATION

1.1 ADMINISTRATION

1.1.2.1 TECHNICAL ADMINISTRATION

Management and technical administration of the USGS Mission is under the direction of Kenneth A. Sargent, Chief of Mission. DGMR representative to the Mission is Ghazi Dairi.

Mr. James D. Leavitt assumed the duties of Chief Geologist on September 10, 1993, replacing Dr. Richard B. Carten. Dr. Carten returned to the domestic program in September and will work as Deputy under Dr. Willis White in the Office of Mineral Resources, Reston, Virginia. Dr. Carten occupied the post of Chief Geologist since January 1991 and did an excellent job in directing the Mission exploration programs. In October 1992, Dr. Carten took on the additional duties of Deputy Chief for Scientific Affairs. He will be greatly missed by all.

Mr. Paul S. Bosch ended his tour of duty on July 11, 1993. He arrived at post from Oman in April 1984 and worked to strengthen the Mission library and archives. In 1986, he was reassigned to field-based geologic programs, where he worked for seven years on ophiolites, and on nickel and gold deposits. The Mission wishes Paul well in his future endeavors in the United States and Oman.

Dr. George V. Albino arrived at post on August 8, 1993 from USGS-Reno (Nevada). He has joined the Mission's mineral exploration team. In Reno, Dr. Albino was with USGS Branch of Western Mineral Resources where he worked on the North American Mineral Resource Appraisal Project, specifically studying deposit models and permissive terranes in the Great Basin.

Dr. Bruce M. Walker returned to the domestic program September 22, 1993, posted to Tucson, Arizona, where he will serve in the Branch of Western Mineral Resources. Dr. Walker came to the Mission in November 1987. During his time at the Mission, he headed USGS field projects at Bi'r Jarbuah, in the Ishmas gold district, and at An Najadi. We wish him good fortune in his new assignment.

1.2.2.2 NONTECHNICAL ADMINISTRATION

Nontechnical administration is under the direction of George V. DeMeglio, Deputy Chief of Mission for Administration (DCMA).

4. TECHNICAL PROGRAM

4.1 GEOLOGICAL SERVICES TO THE COMMUNITY

4.1.1 GEOLOGIC MAPPING OF THE PHANEROZOIC ROCKS

4.1.1.2.01 Geologic Mapping in the Turayf Basin -- C.A. Wallace (USGS, Denver, Colorado, U.S.A.) and S. Dini

FOREWORD

Six geologic quadrangle maps in the northwesternmost part of the Kingdom are in need of stratigraphic study and geologic revision. Most of the area was mapped some years ago at a scale of 1:50,000, and the geology compiled at a scale of 1:250,000 for release as open-file reports. Proposed work will upgrade the maps for publication in the Geoscience Map (GM) series. A

seventh quadrangle, the At Tubayq quadrangle (formerly named the Al Mudawwarah quadrangle), is now being geologically mapped to complete a comprehensive study of the region. The work is particularly important as the area to be mapped includes known phosphate resources of the Turayf-Al Hamad area and potential resources in the As Sanam area.

SCOPE AND OBJECTIVES

- Continue compilation of At Tubayq quadrangle, continue stratigraphic studies, and begin reports for GM series.
- Continue Tertiary geologic mapping of Hazm al Jalamid-Jabal Unazah (31D/32D), Wadi as Sirhan (30C), and Thaniyat-Turayf (29C) quadrangles.
- Compile new geologic data on Ash Shuwayhitiyah quadrangle (30D); complete revisions to text and figures and submit to Mission for review.
- Continue geologic studies in Al Jawf quadrangle (29D) and continue preparation of report.
- Begin revisions to text and maps of Turayf-An Nabk (31C-31B) quadrangles.
- Provide GM pre-publication copies by year end 1994.

SCHEDULE

Start Date:	October 1991
Expected Task Completion Date:	June 1994
Anticipated Report Transmittal Date:	Progress report January 1993. Transmit final copy of the 6 maps to DGMR for preparation and printing by December 1994. GM maps to be prepared, printed, and issued as soon thereafter as possible.

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	YES
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

S.M. Dini conducted field studies during July, 1993 in the Ash Shuwayhitiyah quadrangle (sheet 30D), in the Al Jawf quadrangle (29D), and in At Tubayq quadrangle (29B).

Ash Shuwayhitiyah quadrangle

During the course of field work in this quadrangle, Dini located a phosphatic bed in the Sha'iba Member of the Jauf Formation that was composed of fish-bone fragments, and the P_2O_5 content was 5.5 percent. Similarly, in the Jubah formation, Dini located a phosphate-bearing zone near the top, and this bed had a phosphate content of 2.85 percent. Compilation work in this quadrangle combined previously acquired field data and drill-hole data to define the contact between the upper part of the Aruma Group and the lower part of the Jalamid formation in the eastern part of the quadrangle. This work determined that the Thaniyat phosphorite member of the Jalamid formation does not extend to the east and southeast in the Ash Shuwayhitiyah quadrangle and that the Kuwaykabah member of the Jalamid formation rests directly on the Badanah formation of the Aruma Group. These results were compiled on the Ash Shuwayhitiyah quadrangle and forwarded to C.A. Wallace in Denver for inclusion in GM-126. In addition, as shown in the table below, the drill-hole data (Task 4.2.6.2.01) confirmed the occurrence of phosphorite in the Ghinah phosphorite member and in the Hawsa member of the Mira formation in the northern part of the quadrangle. The phosphorite occurrence in the Hawsa member is newly discovered, and the resource potential of that phosphorite had not been evaluated previously.

Phosphate Data Table

Age	Formation	Member	Internal in meter/depth		P_2O_5	Thickness in m
			From	To		
Eocene	Mira	Hawsa	4.50	5.00	12.34	0.50
	Mira	Hawsa	5.00	5.50	11.15	0.50
Paleocene	Mira	Ghinah	15.00	15.50	10.48	0.50
	Mira	Ghinah	15.50	16.00	15.57	0.50

Al Jawf quadrangle

Field geologic studies in the Al Jawf quadrangle showed that the Thaniyat phosphorite member of the Jalamid formation contained a bed that was rich in fish-bone fragments, and this 0.80-m-thick bed contained 13.53 percent P_2O_5 . Geologic maps were completed of the terrane around Al Jawf city and the data were compiled at 1:50,000 for eventual reduction and compilation on the Al Jawf quadrangle map sheet.

At Tubayq quadrangle

Four days of field work in the southwestern corner of this quadrangle determined the principal geologic units in the Qassim and Sarah Formations, and field work outlined the general extent of those rock units. Cooperative work between the USGS and BRGM will refine the distribution of those units.

Turayf-An Nabk quadrangles

On September 5, 1993, Robert Fraser (USGS-Office of Scientific Publications, Reston) arrived at post for a three-week TDY mission, attached to the USGS Technical Reports Unit, where much of his time was spent on preparation of the Turayf-An Nabk (GM-125) and Ash Shuwayhitiyah quadrangle (GM-126) sheets for production and outside contracting.

Wallace returned to Mission work in September, 1993 after spending June through August on domestic research projects. September work for the Mission consisted of making final revisions to the Turayf-An Nabk quadrangle (sheets 31C and 31B) after two reviews to prepare the report for final editing and preparation for production.

TASK 4.1.1.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Field Mapping	■ ■		■ ■	■ ■			■ ■					
Data Compilation	■ ■ ■ ■	■ ■ ■ ■	■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■	■ ■ ■ ■	■ ■ ■ ■			
Computer Model.												
Report Writing	■ ■ ■ ■	■ ■ ■ ■	■ ■	■ ■	■ ■				■ ■ ■ ■			
Technical Review				■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■						

4.1.3 GENERAL ASSESSMENT OF GEOHAZARDS

4.1.3.2.01 General Assessment: -- H. Swolfs and S. Bamufleh

FOREWORD

Awareness of geohazards in the Kingdom has steadily increased in the last several years. Subsidence, volcanic hazards, earthquakes, and landslides are known geologic hazards in specific parts of the Kingdom and may

constitute threats in less obvious places. An evaluation of known and potentially hazardous areas is of high priority.

SCOPE AND OBJECTIVES

This preliminary overview study of the apparent geohazards in the Kingdom is designed to take no more than one year and is proposed to do the following:

- Identify specific geohazards that could affect the Kingdom.
- Outline areas believed to be most at risk for specific

geohazards at a map scale of approximately 1:4 million.

- Make application to existing hazards, where models are available.
- Grade risks within each geohazard where feasible.
- Complete a summary report and recommend follow-up studies by 07/1414 (01/1994).

SCHEDULE

Start Date:	1991
Expected Task Completion Date:	Fourth quarter, 1993
Anticipated Report Transmittal Date:	Summary report - January 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None this quarter.

QUARTERLY WORK SUMMARY

General Assessment

A draft manuscript on the General Assessment of Geological Hazards, Kingdom of Saudi Arabia by H. Swolfs is in revision following a comprehensive technical review by two peers. Similarly, a 1:4,000,000 scale geohazards map compiled by K. Bankher has been reviewed and returned for further revision. Both these products will be submitted to TRU during the fourth quarter.

Flash-flood Hazard Assessment

The digital compilation of the principal drainage basins along the western escarpment has been completed and editing of the database is in progress. The Southern Hijaz, Tihamat ash Sham, and Asir 1:500,000-scale geographic map sheets were used to extract information on wadi courses, catchment areas, and drainage-system boundaries.

Personnel this Quarter

During this quarter, Mahmoud Shanti joined the Geohazards Section.

TASK 4.1.3.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■ ■ ■ ■					■						
Library Studies		■ ■ ■ ■	■ ■ ■ ■		■ ■	■						
Field Work		■		■								
Laboratory Study												
Data Compilation				■ ■		■ ■						
Map Compilation			■				■ ■	■ ■ ■				
Report Writing				■	■ ■		■ ■		■ ■			
Technical Review								■	■ ■			

4.1.3.2.02 Earthquakes: -- H. Swolfs

FOREWORD

Evidence of historical and geologically recent earthquakes in the Kingdom attest to the need of assessment of this potential geologic hazard. Earthquakes in Yemen (1982), Haql (1983), and Biljurshi (1985) illustrate the current nature of the hazard. Evidence of faulted and offset coral reef limestone (dated at 24,000 years) south of Jeddah indicate the potential threat to coastal towns and cities.

Ground shaking, surface faulting, and earthquake-induced ground failure can all be expected to result from an earthquake and could cause extensive loss of life and damage to property. On-site investigation of all significant earthquakes should be documented. An overall study is needed to assess areas most at risk and serve as a base-line study on which future task groups can initiate mitigation measures.

SCOPE AND OBJECTIVE

This project is an ongoing task and proposes the following:

- Review literature on earthquakes in the Kingdom and in adjacent areas. USGS Bulletin 1868, *Probabilistic estimates of seismic ground-motion hazard in western Saudi Arabia*, by Thenhaus and others, 1989, is an excellent starting place.
- Initiate studies of selected historical and contemporary earthquakes through field inspections,

as time permits. Emphasis should be on major cities, industrial centers, and major access routes.

- Make on-site investigation of significant earthquakes as they happen.
- Initiate studies on secondary ground-failure hazards.
- Establish liaison with other concerned government agencies through DGMR.
- Complete summary report by 07/1415 (12/1994).

SCHEDULE

Start Date:	January 1993
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Progress report - January 1994 Summary report-December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Seismic hazard assessment

An in-house catalog of historical and instrumental earthquake data containing over 300 entries has been compiled from various primary sources; principally from materials published by the United

States National Earthquake Information Center, in Golden, Colorado. This database for the Arabian tectonic plate has been entered into Techbase for quick and easy plotting of all or parts of the earthquake catalog as figures and plates. Additional primary sources of earthquake data will be obtained on a regular basis through annual subscriptions.

Monthly bulletins for the months of May, June, and July, received from the King Saud University Seismological-Geophysical Observatory in Ar Riyadh, through the Directorate General of Mineral Resources, have been reviewed for earthquake activity within the Arabian plate.

TASK 4.1.3.2.02 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■									
Library Studies				■ ■ ■ ■	■ ■							
Field Work												
Laboratory Study												
Data Compilation					■ ■ ■	■ ■	■ ■ ■	■ ■ ■	■ ■ ■			
Report Writing												
Technical Review						■	■	■	■			

4.1.3.2.03 Volcanoseismic Hazards: Volcanic Monitoring - Harrat Rahat and Harrat Khaybar -- A. Showail and J.C. Wynn

FOREWORD

Fissure eruptions of olivine basalt have occurred in recent times (1256 A.D.) in the Harrat Rahat lava field near the holy city of Al Madinah, and probably as recently as 1937 at Dhamar in North Yemen. It is likely that many historical eruptions have gone unrecorded. At Harrat Rahat a linear zone of fumaroles appears to be the focus of increased seismic activity with fairly shallow epicenters. This zone would likely exhibit increased seismic activity before any extrusion of lava. Currently, portable seismographs form a monitoring network. An improved telemetered network would provide better and faster monitoring of site activity. A larger network utilizing proven telemetry techniques and computer digital recording will provide support for geodetic monitoring of ground deformation. During this project year, a Global Positioning System (GPS) receiver will be used to supplement existing deformation measurement techniques.

An ongoing, regional gravity survey of the extensive harrats north and south of Al Madinah includes 6 1/2 quadrangles already covered. The goals of the regional survey are to determine the source vent configuration of the harrats if sufficient density and or magnetic

susceptibility contrast exists between the basalts and the underlying rock.

In addition, geophysicists will periodically measure a 30-km long precise gravity line to monitor any swelling or contracting of the land surface. Additional precise gravity surveys can be measured as our understanding of the subsurface increases to determine slight changes in elevation at the earth's surface caused by swelling or withdrawal of a magma reservoir at depth. Such surveys can determine elevation changes within 3 cm (0.01 milligals) and are independent of horizontal distance. Conventional measuring devices monitor changes in the horizontal dimension and provide little or no detailed vertical data. The use of a helicopter allows a geophysicist to measure changes of elevation along a 30-km line in harrat terrain in one day.

Audio-magneto-telluric (AMT) surveys have proven useful elsewhere in the world in mapping steam, hot water, and magma at shallow to intermediate depths in volcanic provinces. Depending on the levels of noise, digital AMT methods might be used to complement teleseismic and gravity methods to monitor the state of the subsurface beneath Harrat Rahat.

SCOPE AND OBJECTIVE

- This is an ongoing task.
- Continue installation of the telemetered seismic network.
- Monitor and document seismic activity at Harrat Rahat, using the existing portable seismic net now in place, and later, using the new telemetered seismic network.
- Monitor horizontal and vertical land movement.
- Monitor change in temperature of ground water and fumaroles.
- Inspect areas of fumarolic activity on Harrats Rahat and Khaybar, and monitor on a regular basis.
- Run one or two precise gravity profiles over the seismically active part of the harrats and onto Proterozoic rocks away from the harrats, to determine elevation changes to within 3 to 5 cm (.01 milligals) over horizontal distances of 30 km or more.
- Undertake regional gravity surveys over the two harrats and nearby Proterozoic rocks.
- Search for the sources (deep vents) of the basalt flows using gravity and magnetic data wherever the data permit and it proves to be feasible.
- Obtain deep resistivity information via AMT surveys over the parts of Harrat Rahat thought to be tectonically active.
- Complete summary report by 07/1415(12/1994).

SCHEDULE

Start Date:	January 1990
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Progress report - January 1993 Summary report-December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	YES
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	YES
f) Editing in progress	NO
g) Completed	NO
Delays:	None this quarter

QUARTERLY WORK SUMMARY

Telemetered seismic network

Jamal Showaly and Ismail Khoja continue to monitor eight stations of the telemetered seismic network at Al Madinah, working under the supervision of Abdullah Showail and Abdul-Rahman Kinkar. A large new hard disk was installed in the COMPAQ data-acquisition computer, but limitations in the 4-year old COMPAQ system BIOS are hampering its efficient utilization. Data are now routinely added to a database of events in order to facilitate rapid response to inquiries from the DGMR. Superficial events in the Al Madinah area are being routinely followed-up by Showaly and Khoja as they occur; these follow-up efforts are aimed primarily at identifying and thereby eliminating any man-made sources detected by the network, such as explosions at construction sites. Routine analysis and downloading of data are carried out daily by Showaly and Khoja, and data are transported to Jeddah weekly. We are striving to get a dedicated telephone line to the Al Madinah camp installed that will permit us to transfer data to Jeddah immediately after we detect any unusual events.

Elliot Endo continued work on the seismic installation report in the United States. He plans to return to Jeddah in early January 1994/Rajab 1414 to make a first year's evaluation of events detected by the Al Madinah seismic array. Abdul-Rahman Kinkar has returned from extensive sick leave following a heart attack in Denver during May, and is beginning the compilation of the final seismic report for all events detected on the portable seismic network during 1992.

Harrats Rahat and Khaybar gravity studies

Two inoperable gravity meters were shipped to Austin, Texas, for repair. We anticipate their return in November or December. The next occupation of the Al Madinah Gravity Profile Level Line is scheduled for early January 1994/Rajab 1414. This profile is important because it gives us very precise control on elevation changes caused by any inflation of the volcanic field by emerging magma. With the horizontal control provided by geodetic-level Global Positioning System units and the newly-installed seismic monitoring network, we now have the most sophisticated monitoring system in the world. An imminent volcanic eruption should be reasonably predictable by careful analysis of data from these systems.

TASK 4.1.3.2.03 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■		■	■								
Library Studies												
Field Work	■■■				■■■■	■	■					
Laboratory Study												
Data Compilation	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■			
Report Writing	■■			■								
Technical Review												

4.1.3.2.04 Ground Failure -- K. Bankher

FOREWORD

Geohazards caused by ground failure may be divided into subsidence, landslides, and expansive soils. In the Kingdom, subsidence is currently the most serious problem. Ground-water withdrawal removes support for overlying rocks and causes collapse at the surface. Recent problems with subsidence have occurred in Al Kharj (in the central province). Collapse may also occur

in coastal sabkhas when water soluble salts are dissolved by percolating rain water or ground-water. Potential for landslide failure exists all along the Asir Escarpment and other areas of rugged terrain. Expansive soils, generally related to swelling clays, may pose ground-failure problems locally.

SCOPE AND OBJECTIVES:

- This is an ongoing task.
- Begin identification of areas of ground failure most at risk.
- Attempt to grade risks within each type of ground failure.
- Provide general basic data where preventive practices could mitigate the effects of or prevent future ground failure.
- Establish liaison with other concerned government agencies through DGMR.
- Perform, where resources and time permit, limited studies of historical and contemporary ground failure through field investigations. Emphasis should be on major cities, industrial centers, and major access routes.
- Determine, if possible, which geophysical methods (seismic refraction, gravity, ground radar, other) would be most useful for ground subsidence studies.
- Complete summary report by 07/1415 (12/1994).

SCHEDULE

Start Date:	January 1993
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Summary report December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None this quarter.

QUARTERLY WORK SUMMARY

Wadi al Yatimah

Work on the water-well inventory in Al Yatimah valley has been suspended during this quarter to devote our efforts on an urgent study of the solid-waste landfill area west of Jeddah. An index map

of the Al Yatimah and An Naqi valleys was digitized to provide the required geographic base for the GPS network information. USGS program GSMAP, version 8, was used to digitize a merged topographic stable base at a scale of 1:50,000.

TASK 4.1.3.2.04 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■■■■	■■■■	■■■■			■■						
Library Studies					■■■■	■						
Field Work				■		■						
Laboratory Study												
Data Compilation				■■■								
Map Compilation							■■■■	■■■■	■■■■			
Report Writing												
Technical Review												

4.1.3.2.05 Hazardous Waste and Radon -- H. Hashem and P. Schmidt

FOREWORD

Naturally occurring toxic substances such as lead, cadmium, mercury, selenium, arsenic and radon have been known for many years to be serious health hazards to humans and animals throughout the world. As the Kingdom of Saudi Arabia expands its urban areas and becomes industrialized, the risks from hazardous materials will increase. The gradual seepage of soluble toxic substances into soils and surficial deposits and their eventual contamination of the water table constitute the greatest and longest lasting hazard to the populace. The seriousness of present-day contamination has yet to be

determined and baseline documentation is needed. Toxicity levels for a variety of substances should be checked regularly, especially at ground-water extraction localities and downstream from current and old mining sites. Baseline measurements should also be made in areas of naturally occurring anomalous lead, arsenic and radon. The selective incorporation of certain toxic elements by indicator plants has been known for several years and should be tried for clues in locating baseline surveys.

SCOPE AND OBJECTIVES:

This task will include the following :

- Begin identification of naturally occurring toxic substances in the Kingdom of Saudi Arabia.
- Identify areas of possible risk.

- Start characterization of geology and hydrology of one or more areas at risk.
- Summary report by 07/1415 (12/1994).

SCHEDULE

Start Date:	January 1993
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Summary report December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None this quarter.

QUARTERLY WORK SUMMARY

Radon

Work continued with the assembly of uranium occurrences in the Precambrian shield and the Paleozoic to Mesozoic cover-rock areas as determined from various aerial surveys. Efforts are underway to correlate these occurrences with population centers and permeable soils. A general radon-potential map covering the area between 25-27° N and 36-40° E in the Arabian Shield is

being compiled. The aeroradiometric anomaly map for the Precambrian shield area referred to in the second quarterly progress report has been digitized using the USGS program GS-MAP, version 8. Preliminary field reconnaissance trips have been made to the Ranyah and Qassim regions.

In cooperation with the USGS Radon Group in Denver, Colorado, soil-gas monitoring equipment has been ordered for use in the Kingdom.

Hazardous waste

Work continued with a ground and air reconnaissance of the area east of Jeddah, near Briman, documenting the raw-sewage dumping activities and their ground effects. These data (including a photographic and video record) are to be compiled and plotted on suitable base materials at a scale of 1:25,000. Limited research of the literature on the environmental effects of crop irrigation with raw sewage has been carried out.

Ground and air reconnaissance and photo and video documentation of the handling of raw sewage continued in and around the Jeddah area during the later part of the third quarter, focusing primarily on the use of legal- and illegal-dumping areas. Overflights of the area, mainly east of the Ring Road, were carried out on September 21 and 29 (16 and 24 Rabi II) as well as numerous trips to the field. As a result of this reconnaissance, a focus on the legal-dumping area at the head of Wadi al Hatal (fig. 2) became of primary interest, namely because of the increased dumping activity and its profound effects on the holding ponds and the adjacent and downslope areas.

As reported last quarter (USGS QR-93-2), one of the ponds in the legal-dumping area had breached a retaining berm resulting in a flow of effluent downstream (fig. 3). A revisit to this area this quarter showed that downcutting of the breached berm substantially lowered the pond levels (draining one upper pond completely) and downstream runoff had increased drastically. Moreover, dumping in this area has greatly intensified—earlier visits to the area witnessed either none or one truck dumping whereas recent visits to the area show continuous dumping by numerous trucks. Conversations with local residents indicate that as many as 300 trucks per 24-hour day are using this area. The most common tankers used in the transportation of waste water are the Mercedes 911 tanker, with a holding capacity of 8,000 ltrs., and Mercedes 1924 tanker, with a holding capacity of 16,000 ltrs. The effects precipitated from this usage are (1) creation of an elevated and contaminated water table (local pits that were dry less than a year ago now have near-surface ponding) (fig. 4), and (2) constant and increasing creek-size runoff from the legal dumping area to a lake just east of the Saudi Aramco Tank Farm (approximately 8 km downstream). A water-sampling program, water-table study, and dumping-volume compilation are now underway.

Other activities conducted this quarter include the preparation of a 1:25,000-scale stable base for compilation and plotting all data in and around the Jeddah area and the establishment of a retrieval archive system of all slides and photographs taken since the onset of the Hazardous Waste project.

<

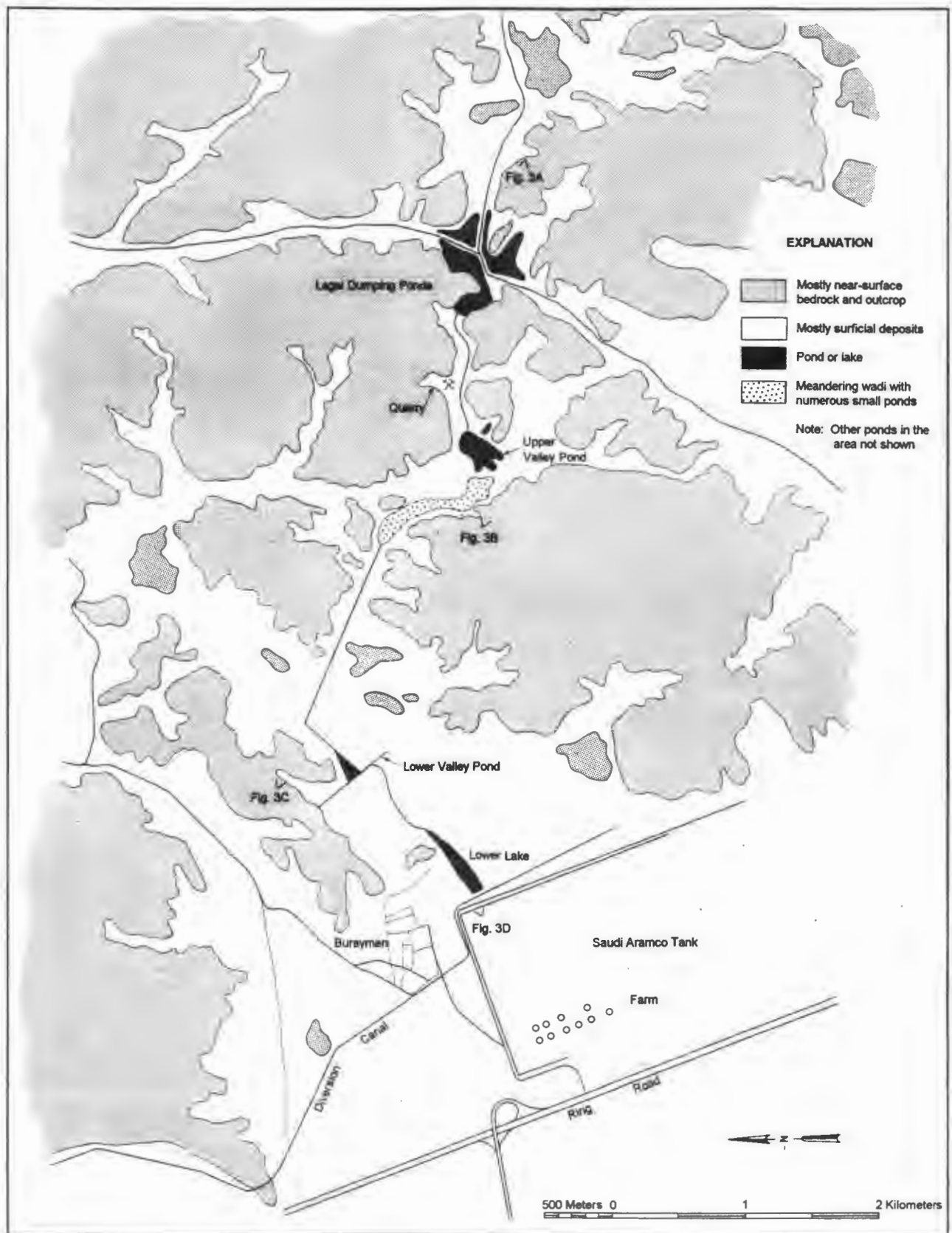


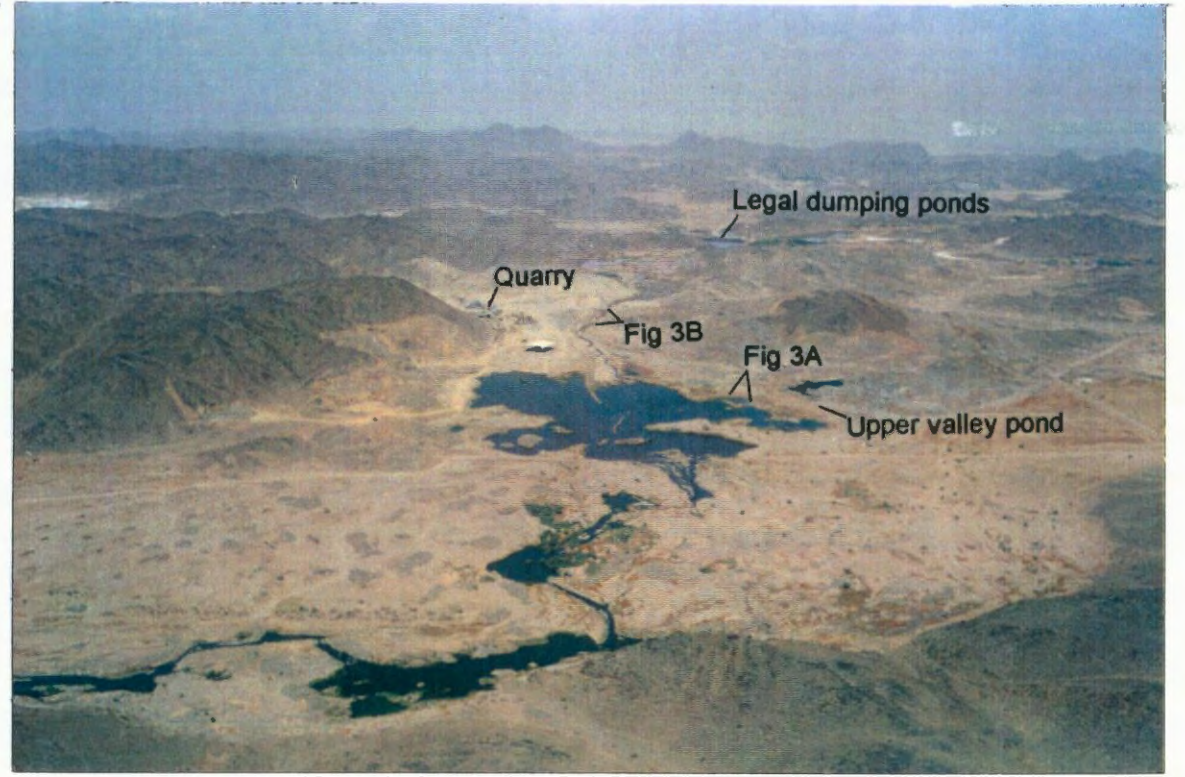
Figure 2. Schematic sketch map showing the location of the legal dumping ponds and the downwadi course, along Wadi al Hatal, to the lower lake.

Figure 3. Oblique aerial photographs, taken on March 16, 1993 (12 Ramadan, 1413) showing: **(A)** Legal dumping ponds at the head of Wadi al Hatal; **(B)** Reverse-angle photograph of the upper valley pond and meandering wadi channel; **(C)** Lower valley pond; and **(D)** The lake just east of the Samarec Tank Farm. Shortly after these photographs were taken, the lower valley pond overflowed and the effluent now flows downwadi to the lake. *Foldout page*

A.



B.



C.



D.



A.



Figure 4. Photographs showing: (A) The near-surface water table in the basin containing the upper valley pond; and (B) Creek-sized runoff of sewage from the legal holding ponds.

B.



Solid-waste Landfill

An urgent study of the area near the solid-waste landfill of the City of Jeddah (fig. 5), requested by the Municipality and authorized by the Directorate General of Mineral Resources, has been completed. The study consists of two parts: (1) the construction of a topographic base at a scale of 1:10,000; and (2) the examination and description of the soil and weathered-bedrock profile near the landfill. An oral report on the results of the study was given during discussions between DGMR and municipality officials and the writing of a summary report is in progress. This report will be submitted to the Directorate General of Mineral Resources next quarter.



Figure 5. Aerial view of the solid-waste landfill in Wadi Nakhil near Jeddah.

TASK 4.1.3.2.05 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Field Work												
Laboratory Study												
Data Compilation												
Report Writing												
Technical Review												

4.1.3.2.06 Emergency Response Investigations -- P. Schmidt, H. Swolfs, and S. Bamufleh

FOREWORD

Each year the DGMR receives urgent requests for assistance with geohazard problems. This is an assigned responsibility that is usually carried out at the request of the Ministry of Interior. These are emergency responses for immediate action to monitor natural and man-made

phenomena. Investigations such as earthquakes, ground subsidence, boulder field stabilization, geothermal problems, and lake bank stabilization problems have provided recent examples of typical emergency investigations.

SCOPE AND OBJECTIVES:

This is an ongoing task that proposes the following:

- Maintain a team of scientists for immediate investigation of a wide variety of phenomena.
- Have available portable seismic, geothermal,

geophysical, photographic, and surveying equipment together with aerial photographs and geological maps as required to produce confidential reports rapidly as required.

SCHEDULE

Start Date:	January 1993
Expected Task Completion Date:	As needed
Anticipated Report Transmittal Date:	As soon as possible after emergency action

PROGRESS

Status:	N/A
Delays:	N/A

QUARTERLY WORK SUMMARY

Hot Water

Responding to an article in the Arabic newspaper *Okaz*, a one-day field trip was organized by DGMR to document the reported hot-water spring located near Ghumayqah Village. On Saturday, September 25th (20 Rabi II), Philip Aruscavage, Sameer Bamufleh, and Paul Schmidt left Jeddah via a Toyota Landcruiser for the town of Al Lith, then traveled 27 km east to Ghumayqah Village. Acquiring a guide, they then proceeded 20 km up Wadi Al Lith to the hot-spring site, located at lat 20°7'40.2"N., long 40°28'15.1"E. The hot-water spring is situated in a valley bottom at the confluence of two major wadis and percolates out of granitic bedrock (fig. 6). Flow from the spring is very low and temperatures measured at the discharge site were 89-90° C, cooling down substantially within a few meters downstream. Water samples taken from the spring indicate a pH of 7.5 (normal water pH ranges between 6.5-8.5) and lab analyses indicate a highly saline content (table). The ground surface was crusted primarily with NaCl (sodium chloride) crystals and wildlife (mainly frogs) was abundant in near-by ponds.

Table showing chemical analyses of the Ghumayqah hot-water spring (in ppm)*

	Cl ⁻	SO ₄	HCO ₃	Na	K	Ca	Mg
Ghumayqah hot-water spring	730	538	36.6	430	52	14.4	1
<i>Normal potability-water range</i>	<i>3-100</i>	<i>5-100</i>	--	<i>3-100</i>	<i>1-10</i>	<i>10-100</i>	<i>5-30</i>
<i>Maximum</i>	<i>250</i>	<i>250</i>	--	--	--	<i>200</i>	<i>100</i>

Total dissolved solids = 2.65 mg/ml

Recommended maximum = 1,000 mg/ml

-- Indicates no data

* Chemical analysis done by the USGS-DGMR analytical laboratory. Water-quality data provided by P. Aruscavage (written commun., Oct. 2, 1993).

During the on-site inspection of the spring, it was noted that large debris deposits (fig. 7) were present in the area, indicating high-energy water traveling downstream during times of intense rainfall. Additional studies should be carried out to document the potential flood hazards in and along these wadi areas.



Figure 6. Photograph of the hot-water spring site. Philip Aruscavage (left) and Sameer Bamufleh (right) collecting water samples and taking water temperature while the local guide (top) observes.



Figure 7. Debris deposit just below the hot-water spring site. Black-handled knife on limb for scale.

4.2 MINERAL EXPLORATION

4.2.2 MINERAL RECONNAISSANCE OF SELECTED REGIONS

4.2.2.2.01 Geologic Reconnaissance - General -- H.W. Schull, P.R. Johnson, G.V. Albino and A. Jastaniah

FOREWORD

Reconnaissance is an iterative process that evaluates, interprets, and checks information about the geology and mineralization of the Kingdom in the light of developments in exploration and extractive technology, a changing economy, new metallogenic concepts, and new

geologic data. Reconnaissance surveys define limits of regions with gold potential, provide control for reconnaissance geochemical and geophysical surveys, and identify targets for prospecting or mineral-belt mapping.

SCOPE AND OBJECTIVES

The fourth year of a five-year project includes:

- Continue compilation and assessment of geoscience data acquired from DGMR sources, adjacent countries, and specialists.
- Continue review of databases on world-wide occurrences and mineral deposit models applicable to Saudi Arabia.
- Continue geomorphologic research to evaluate geochemical surveys, to understand gossan formation, and to outline areas of secondary enrichment by weathering.
- Identify and evaluate prospects throughout the shield.
- Provide results of selected prospect studies by 07/1414(01/1994).
- Publish open-file compilation of shield geology (1:500,000 scale) by 07/1415(12/94).

SCHEDULE

Start Date:	1990
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Progress report -January 1994. Summary report - December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NO
e) Technical review	YES
f) Editing in progress	YES
g) Completed	NO
Delays:	None this quarter.

QUARTERLY WORK SUMMARY

Prospect Studies - Reconnaissance for Gold Exploration Projects

No field work was done during the third quarter although a number of field reconnaissance visits were made by H.W. Schull, G.V. Albino, R.L. Lewis, P.R. Johnson, and J.D. Leavitt. For Albino and Leavitt, who are new to Saudi Arabia, the trips also constituted familiarization tours. In August and September two trips were made to the Al Wajh-Al Qubbah area, and included geologic examination and logistics planning for work at the Al Qubbah, Ash Shuwatah, and Umm al Qurayyat prospects. In September a visit was made to the Bil'iwiy-Murayjib area and to SCPM concessioned areas. This familiarization visit included stops at Sukhaybarat, Mawan, and Bulgah.

Mineral reconnaissance work by Schull was restricted mainly to library research and data compilation, and the selection of gold exploration target areas. Field exploration, as 1:1,000-scale mapping and sampling, is planned for the fourth quarter in the Aqiq Ghamid (MODS 024) area, initially away from the main ancient mining site. Work planned for the Al Qubbah area will be under the direction of Albino.

Reports by Schull on field work done in the second quarter are in progress for Lugatah (MODS 628) and Mokhyat (MODS 1452).

Study of Tertiary Weathering Processes and the Formation of Supergene Gold Deposits:

No field work was done this quarter. In July, a visit was made to Edinburgh University Geography Department for discussions with Dr. M. Summerfield about geomorphologic observations made in western Saudi Arabia during the past year. During the course of discussion, the point was made that the datable sub-Tertiary land surface preserved from erosion by the superimposition of Tertiary basalt in western Saudi Arabia is more extensive than such surfaces in many other parts of the world. Because of this, western Saudi Arabia provides information about a datable surface that is unobtainable elsewhere, and encourages a continuation of the effort to reconstruct the Tertiary landform, to characterize Tertiary weathering processes, to document Tertiary weathered profiles and geochemical processes, and to demonstrate the relation between erosion and uplift.

During the coming quarter, it is planned to keyboard topographic data for profiles across the west Arabia pediplain, Red Sea escarpment, and coastal plain south of the Ad Damm fault so that profiles can be printed and compared with profiles obtained earlier for the region north of the Ad Damm fault. XRD analysis of clay minerals and chemical analysis of samples from selected profiles will continue.

Compilation of Neoproterozoic Geology

Two of the six planned 1:500,000-scale sheets showing the Neoproterozoic geology of western Saudi Arabia have been finished and are being readied by TRU for distribution. Compilation of the north-central sheet will start early in 1994.

TASK 4.2.2.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies							█		█			
Field Work				████	████	████						
Drill/Trenching												
Laboratory Study												
Data Compilation	██	██	██				█	█	█			
Report Writing								█	██			
Technical Review												

4.2.2.2.02 As Siham Gold Belt -- H.W. Schull

FOREWORD

Gold-quartz vein mineralization (Sukhaybarat-type) is primarily associated with bimodal gabbro-monzogranite plutonism (660-620 Ma) that occurred during the cratonization of the Arabian Shield. Plutonism of this type is most voluminous in the southern part of the Najd zone. Pre-existing deep-seated structures localize intrusions and subsequent hydrothermal activity. The intersection of the southern Najd zone and the Nabitah zone in the As Siham belt offers an ideal structural setting for

the formation of hydrothermal gold-quartz systems. Riofinex work showed that the density of quartz-vein gold occurrences within the Shield is highest within this region. Veins are most abundant in metavolcanic and volcanoclastic roof-pendants and screens of the As Siham formation. The As Siham mineral belt includes ancient workings at Quwaymah, Jabal Abra q Humayrah and As Siham (100,000 t > 5 g/t) that have not been fully evaluated.

SCOPE AND OBJECTIVES

First year of two-year project:

- Integrate existing detailed observations made by Riofinex and BRGM and add new intermediate-scale geologic mapping and sampling to determine (1) structural controls of quartz-gold vein mineralization and (2) the location of ore bodies beneath cover of alluvium and wind-blown sand.
- Begin detailed follow-up on any new prospects that may be discovered.
- Provide summary of progress and geologic sketch maps of regional geology by 07/1414 (01/1994).

SCHEDULE

Start Date:	1993
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Progress report - January 1993 Summary report - December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NO
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None this quarter

QUARTERLY SUMMARY

Library studies of data compilation started. Field work will begin in the fourth quarter.

TASK 4.2.2.2.02 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation								■ ■ ■ ■	■ ■ ■ ■			
Library Studies								■ ■ ■ ■	■ ■ ■ ■			
Field Work												
Drill/Trenching												
Laboratory Study												
Data Compilation												
Report Writing												
Technical Review												

4.2.3 FOLLOW-UP EXPLORATION OF SELECTED DISTRICTS

4.2.3.2.01 Hamdah Mineral Belt -- Eyad Jannadi and M.B. El-Komi

FOREWORD

Completion of report on the Hamdah mineral belt which surrounds the economic gold deposit at Hamdah.

SCOPE AND OBJECTIVES

- Complete final phase of report writing.
- Receive technical reviews.
- Publish report by 10/1413 (04/1993).

SCHEDULE

Start Date:	October 1990
Expected Task Completion Date:	August 1992
Anticipated Report Transmittal Date:	Progress report January 1993. Summary Report-January 1993

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

The summary report for this project was turned in to Mission TRU at the end of the quarter.

TASK 4.2.3.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Field Mapping												
Field Sampling												
Lab Analyses												
Data Compilation	■ ■			■ ■ ■								
Report Writing	■ ■ ■ ■ ■	■ ■			■ ■ ■ ■ ■							
Technical Review		■ ■	■ ■ ■ ■ ■	■ ■ ■ ■ ■		■ ■ ■ ■ ■		■ ■ ■	■ ■ ■ ■ ■			

4.2.3.2.03 Bi'r Hamadan Mineral Belt -- P.S. Bosch

FOREWORD

The Bi'r Hamadan mineral belt, extending from lat 18°37'30" to 18°55'10" N, and from long 43°37'30" to 43°38'15" E, is located in the Hamdah-Jabal Riah gold

district about 5 km southwest of the Hamdah ancient workings. A final report, describing and summarizing the area, is in the last stages of preparation.

SCOPE AND OBJECTIVES

- Complete technical reviews.
- Publish report by 10/1413 (corresponding to 4/1993).

SCHEDULE

Start Date:	November 1990
Expected Task Completion Date:	December 1992
Anticipated Report Transmittal Date:	Summary Report - June 1993

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

A summary report for this project, entitled *Bi'r Hamadan mineral belt*, by P. S. Bosch, was transmitted to DGMR during the quarter.

TASK 4.2.3.2.03 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Field Mapping												
Field Sampling												
Lab Analyses												
Data Compilation												
Report Writing	■■■■	■■■■										
Technical Review			■■■■	■■■■	■■■■	■■■■	■■■					

4.2.3.2.04 An Najadi Mineral Belt -- R.S. Lewis., J.A. Al Tayyar, R. Al Otaibi. and M. Ben Talib

FOREWORD

In the Wadi Mahalani - Wadi Sha'bah area, between Uqlat as Suqur and Samirah, are several ancient gold quartz mining sites. Commonly, the quartz veins occur singly or in subparallel swarms in a cross cutting relation to contacts of intrusive rocks and metasedimentary rocks of the Murdama group. Other characteristic features include: (1) arsenic and antimony as associated trace elements; (2) Au/Ag ratios greater than 1; (3) total sulfide contents in the 1-2 percent range; (4) lenticular veins; (5) en echelon vein swarms; and (6) restriction of wall rock alteration and gold mineralization to vein selvages. The marked similarity between these occurrences and that mined at Sukhaybarat recommend

them as exploration targets for Sukhaybarat-type gold mineralization.

The USGS started a gold exploration project in late 1991 at An Najadi (MODS 1272), the largest of these ancient mining sites. Work at Wadi Sha'bah NE (MODS 4234) and E (MODS 4235) commenced in mid-1992. The aim is to discover bulk-minable cyanide-leachable gold deposits.

Work is planned for Agob (MODS 1271), Agob N. (MODS 3896), Wuday (MODS 3273), Ar Rahail (MODS 3272), and Meshahed (MODS 1266).

SCOPE AND OBJECTIVES

The proposed tasks for the second year of a three year project include:

- Descriptions of mineralization, host rocks, and wall rock alteration.
- Drilling and trenching of prospects.

- Estimate of grade and tonnage, where appropriate.
- Detailed surface mapping.
- Ground magnetic and radiometric studies, where appropriate.
- Final report by 07/1415 (12/1994).

SCHEDULE

Start Date:	February 1992
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	December 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Work in the third quarter concentrated on compilation and report writing. A rough draft of the report describing the geology and mineralization of the Agob and Agob North prospects was completed, as was a draft describing the Wuday and Wuday West prospects. Final drafts will be ready for review pending completion of the Meshaheed Prospect report (subproject 4.2.4.2.03).

TASK 4.2.3.2.04 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■											
Library Studies												
Field Mapping	■■	■■		■■	■							
Field Sampling	■■	■■		■■	■							
Lab Analyses			■■	■■■■	■■■	■■■	■■					
Data Compilation				■■■	■	■	■■■■	■■■■	■■■■			
Report Writing							■■	■	■■■			
Technical Review												

4.2.3.2.05 Al Wajh Mineral Belt -- P.R. Johnson, A. Jastaniah, and M. El Komi

FOREWORD

The Al Wajh mineral belt (approximate center 26°15'N, 36°37'E) is a cluster of over 10 ancient mines inland from Al Wajh that worked gold-bearing quartz veins and alteration selvages in a succession of low-grade metavolcanic and metasedimentary late Proterozoic rocks. Individual known gold occurrences are small (<600 kg contained gold) and low grade (<4 g/t). The auriferous quartz veins are discontinuous and localized

in narrow, anastomosing shears. Nevertheless, anomalous gold values are present in bedrock in the district (as much as 60 ppb) and in shear zones that contain little quartz (as much as 4 ppm); low gold values (0.4 ppm) are contained in alluvium collected in the vicinity of ancient mines. These findings suggest a low-grade gold resource may be present in bedrock, weathered zones, and alluvium.

SCOPE AND OBJECTIVES

Project is scheduled for completion in 1993:

- Completion of regional geologic mapping at a scale of 1:25,000 in order to identify structural and possible lithologic control on gold distribution, and the relationship of shear zones to metamorphism and regional deformation.
- Completion of detailed mapping (1:1000 scale and

larger) of selected quartz veins and shear zones in order to determine the structural control and timing of quartz veining and gold emplacement.

- Follow-up of a wadi-sediment survey done in 1992.
- Preparation of a map and report (12/1413) (06/1993).

SCHEDULE

Start Date:

1991 *

Expected Task Completion Date:

December 1993

Anticipated Report Transmittal Date:

December 1993

*(Reported under 4.2.2.2.01 from 1990 to end-1991)

PROGRESS

Status: a) In progress

YES

b) Delayed

YES

c) Abandoned

NO

d) Reinstated

NA

e) Technical review

NO

f) Editing in progress

NO

g) Completed

NO

Delays:

YES, because of effort diverted to technical review and edit of DGMR report entitled *Mineral Resources of Saudi Arabia*.

QUARTERLY WORK SUMMARY

A. Jastaniah continued preparation of the report on wadi sediment geochemistry and P.R. Johnson started compilation of the geologic map of the mineral belt. In September, a visit was made to the belt by J.D. Leavitt, G.V. Albino, and H.W. Schull, guided by P.R. Johnson, to assess present results and to determine the nature of further work.

On the basis of present evidence, Umm al Qurayyat, Ash Shuwatah, Khawr al Arjah, and An Nahdayn #1 warrant further sampling, detailed geologic mapping, and drilling. Discussions were held to plan for this work and to schedule it within the overall work program.

Work on the mineral belt and wadi-sediment geochemistry reports continued during the quarter with the aim of completion by the end of the year.

TASK 4.2.3.2.05 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Field Mapping		■										
Field Sampling												
Lab Analyses						■ ■						
Data Compilation	■ ■ ■	■	■ ■ ■ ■ ■	■ ■ ■ ■ ■				■ ■ ■	■ ■			
Report Writing					■ ■ ■ ■ ■	■ ■ ■ ■ ■			■ ■			
Technical Review												

4.2.3.2.06 Murayjib-Umm Hafra Region -- R.B. Carten, P.S. Bosch, E. Jannadi, M.B. El-Komi, and S. Al Yazidi

FOREWORD

The Murayjib-Umm Hafra region (lat 24°50'N, long 38° 24'E) contains a minimum of 700,000 m³ of gold-bearing (0.05-0.3 g/t) ancient placer workings based upon preliminary work by Riofinex. The most puzzling aspect is the large scale of the workings and the low-grades reported by Riofinex Geological Mission. The large and widespread nature of the workings alone suggest reevaluation, and possible sampling problems and undefined gold source areas reinforce that perception. The gravel placers are as deep as 11.5 m and most of the trenches dug by Riofinex did not reach

bedrock. Thus, the full thickness of the gravels was not sampled by trenching. Churn drills were used to obtain deep samples. The samples that were collected were panned (manually and by mechanical panner) prior to chemical analysis. Fine-grained gold was probably lost during panning and churn drilling. Resampling and reevaluation by the USGS in the Spring of 1992 indicate that a large area near the ancient mining town of Efshaigh should be tested for placer gold by a small-scale processing plant.

SCOPE AND OBJECTIVES

Objectives of a one year project:

- Definition of the regional limits of mineralization by wadi geochemical surveying. Reexamination and remapping of extent and nature of ancient placer workings.
- Excavation of selected placers by bulldozer to insure complete sampling of overburden.
- Large-scale processing of bulk placer ores by a front-end loader, screening plant, and Nelson concentrators.

- Leaching of selected bulk samples by cyanide to test for loss of fine gold during processing.
- Regional mapping and sampling of known bedrock sources of placer mineralization. Exploration for unknown upstream sources of mineralization. Determination of the origin of the placer gold through the use of mineralogical studies.
- Provide report by 07/1414 (01/1994) and recommendations for follow-up studies.

SCHEDULE

Start Date:

1991 *

Expected Task Completion Date:

December 31, 1993

Anticipated Report Transmittal Date:

First Quarter 1994

*(Reported under 4.2.2.2.01 from 1990 to end-1991)

PROGRESS

Status: a) In progress

YES

b) Delayed

NO

c) Abandoned

NO

d) Reinstated

NA

e) Technical review

NO

f) Editing in progress

NO

g) Completed

NO

Delays:

None

QUARTERLY WORK SUMMARY

Efshaigh placer

Analyses and modeling of 21 gravity profiles from the Efshaigh placer grid area in the northwestern part of the Murayjib-Umm Hafra Region were completed by Nimr Arab of the geophysics section during the third quarter. A map of depths to bedrock or compacted rock was produced that indicates the presence of several deep, linear, buried ravines (fig. 8). The average thickness of the Efshaigh placers was found to be about 6 meters.

More than 500 trench heavy-mineral concentrate samples from the grid area were fire-assayed during the quarter. Statistical analyses of the sample set were in progress at the close of the quarter. Preliminary results indicate that bulk and concentrate anomalies occur in an area 550 x 300 m within the grid area.

Regional sampling

Outside of the Efshaigh placer grid area, a total of 215 surface samples were collected from other localities within the Murayjib-Umm Hafra Region. Anomalous bulk gold values (>0.1 ppm Au) suggest areas for follow-up sampling during the fourth quarter (fig. 9). A more detailed investigation of lode and placer potential is planned for the southern part of the region, about 1 km north of Umm Hafra ancient mine.

During the fourth quarter 8 trenches will be dug, if possible to bedrock, to test the depth of the placers. The trenches will be mapped and sampled. Four trenches will be dug in the vicinity of Umm Hafra, where sampling revealed anomalies, and the remaining trenches will be dug northeast of the Efshaigh grid area, close to a suspected gold source.

TASK 4.2.3.2.06 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies	■ ■ ■											
Field Mapping	■ ■	■ ■ ■ ■		■ ■ ■ ■	■ ■							
Field Sampling	■ ■	■ ■ ■ ■		■ ■ ■ ■	■ ■		■	■	■			
Lab Analyses		■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■						
Data Compilation	■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■			■ ■			
Report Writing												
Technical Review												

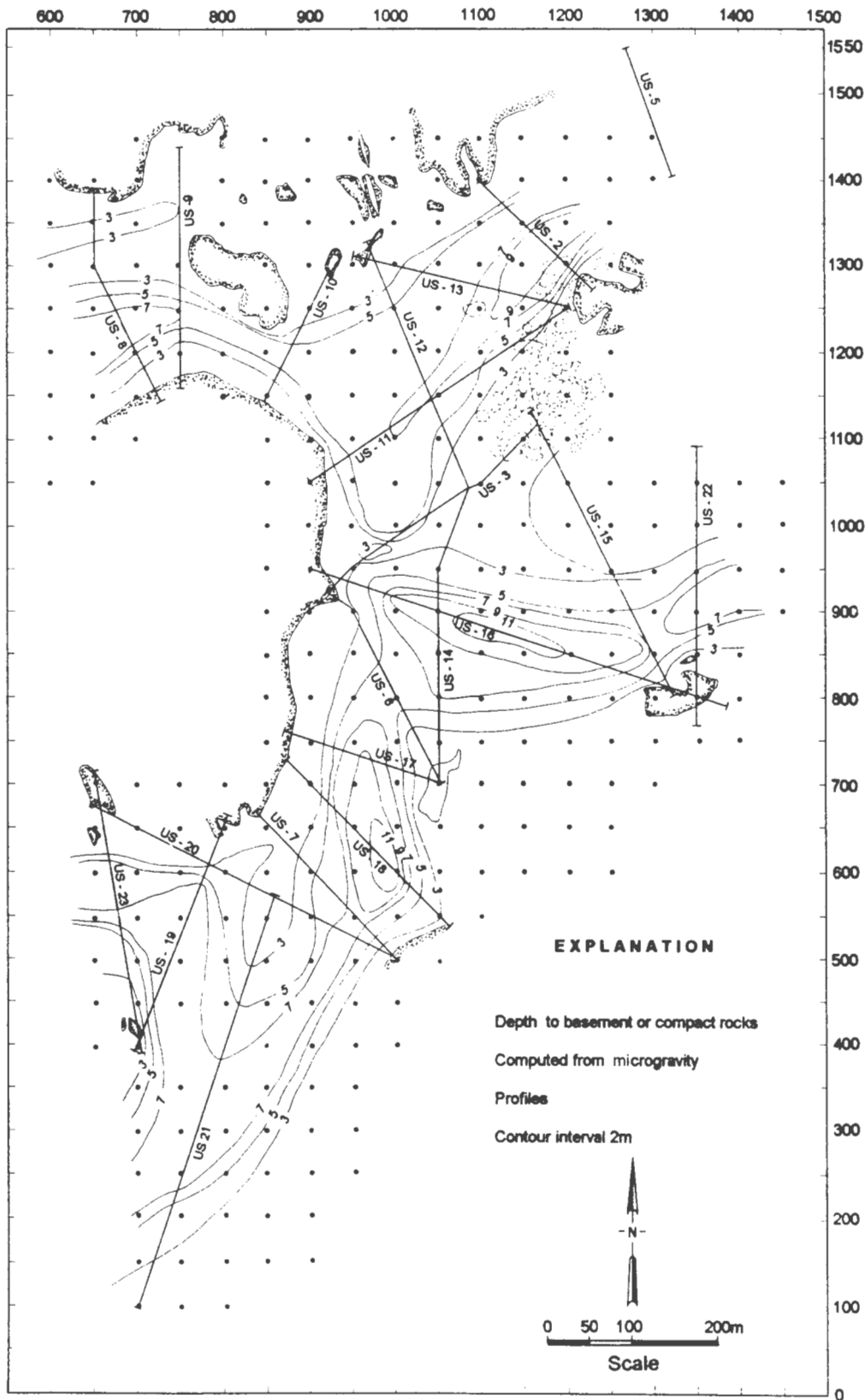


Figure 8. Efshaigh grid area (NW Murayjib-Umm Hafra region), showing the depths to basement or compact rock computed from microgravity profiles. Contour interval 2 m.

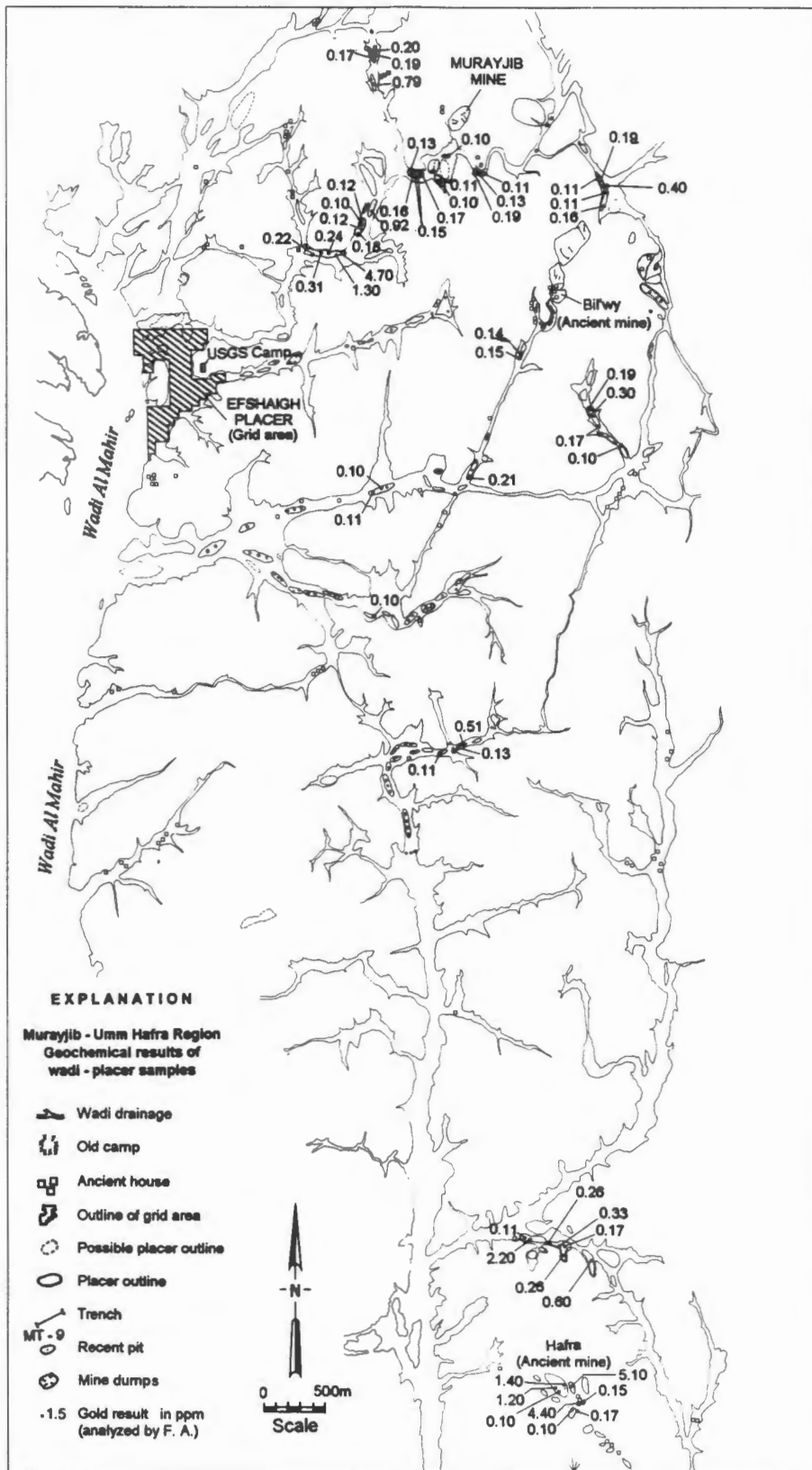


Figure 9. Map of Murayjib-Umm Hafra region showing geochemical results of wadi-placer samples. Efsaigh placer grid area shaded.

4.2.4 ASSESSMENT OF PRECIOUS AND BASE-METAL PROSPECTS

4.2.4.2.02 An Najadi Gold Prospects (MODS 01272) -- B.M. Walker, R.S. Lewis, R. Al Otaibi, M. Ben Talib, and R.P. Christian

FOREWORD

Three contiguous An Najadi prospects are located at lat 26°00'00"N, long 42°05'00"E, and contain some of the most extensive ancient mine dumps and exposed stopes in the Arabian Shield. Three groupings of ancient workings (each defines a prospect) are arrayed along a north-trending belt approximately 4 km long and 0.7 km wide. The stopes follow steeply dipping quartz veins and clusters of veins proximal to two small dioritic intrusions. The geologic setting to the An Najadi prospects is similar to that at Sukhaybarat where the gold-bearing veins are associated with the apical zone of a tonalite intrusion of the Idah suite emplaced into metasedimentary-host rocks of the Murdama group. Dumps were trenched (23 trenches) and partially sampled by Riofinex in 1405. Although their field work ended prematurely, results indicate an average of 3.6 g/t for 33 quartz-vein samples, 1.7 g/t Au for 70 samples of quartz veins plus altered Murdama rocks, and 0.2-0.3 g/t Au for 62 samples of unaltered Murdama, dioritic, and post-ore quartz breccia rocks. Re-mapping and selective sampling of An Najadi trenches were initiated in early 1412 by the USGS.

A 4.5-km long and 1.0-1.5 km wide grid consisting of 50-m spaced stations was surveyed at An Najadi, and elevations were determined for each grid point. Some

2,100 samples were collected at grid stations for chemical analysis as part of a surface-geochemical study. Geologic mapping of outcrops and surficial features was begun in May 1991; sampling of bedrock (horizontal rock-chip channel samples), sampling of dump/tailing overburden (vertical channel samples), and mapping of trench walls were initiated September, 1991. Ground magnetics, CRONE EM, and SCINTREX gamma-ray spectrometer surveys were completed in September 1992; gravity measurements were conducted along North-South stations defining the grid baseline. Detailed filtering and modeling of the magnetic data permit mapping of the key geologic units and alteration in the third or buried dimension, contributing significantly to estimates of the ore reserve. Eight inclined core holes (1,131 m total) were drilled in the Spring of 1992. A total of 47 core holes (1,883 m) and 133 percussion holes (2,222 m) were drilled in the fall of 1992.

The large number of gold-bearing quartz veins, ancient workings, and extensive dumps suggest that there are good possibilities of discovering gold concentrations of economic grade in the region, especially as the economic potential of the prospects has been only partly tested.

SCOPE AND OBJECTIVE

A three-year project is planned. The third year's plans include:

- Percussion and core drilling, if required, based upon 1992 geochemical analyses.
- Complete geologic mapping and core logging.

- Complete petrographic and microbeam studies of mineralogy and petrology.
- Final report and recommendations will be transmitted on or before 07/1414(01/1994).

SCHEDULE

Start Date:

1991

Expected Task Completion Date:

December 1993

Anticipated Report Transmittal Date:

Progress report-January 1993
Summary report-January 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Work in the third quarter consisted of finishing the final report, which was submitted to the Chief Geologist for peer review in late September. Drafting of necessary plates and figures is nearing completion.

Geophysical Support

A geophysical chapter with 11 figures was written to accompany the An-Najadi final report. This concludes a major two-year effort at this site by the Geophysics Section, utilizing gravity, magnetic, and radiometric data.

TASK 4.2.4.2.02 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Site Survey												
Field Mapping	■ ■ ■ ■											
Field Sampling	■ ■ ■ ■	■ ■ ■ ■										
Geophysics		■ ■ ■ ■	■									
Drill/Trenching		■ ■ ■ ■										
Lab Analyses	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■									
Data Compilation				■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■		
Report Writing		■ ■ ■ ■	■ ■	■ ■ ■	■		■ ■ ■ ■	■ ■ ■ ■	■ ■ ■			
Technical Review												

4.2.4.2.03 Meshaheed Gold Prospect (MODS 01266) -- R.S. Lewis, R. Al Otaibi, J.A. Al Tayyar and M. Ben Talib

FOREWORD

The Meshaheed area (MODS 01266) is located in the eastern part of the An Najadi Mineral Belt and contains the following seven prospects: (1) Quartz Hill No. 1; (2) Quartz Hill No. 2; (3) Quartz Hill No. 3; (4) Pluton Northwest; (5) Pluton West; (6) Pluton Southwest; and (7) Pluton Southeast. The prospects are characterized by ancient mine pits located either in dioritic stocks or in

adjacent metasedimentary rocks of the Murdama group. As elsewhere in the An Najadi mineral belt, similarities exist between these prospects and the Sukhaybarat gold deposit that is currently being mined. Thus, there is potential for additional large-tonnage, low-grade, bulk-minable deposits in the Meshaheed area.

SCOPE AND OBJECTIVE

An original plan for prospect evaluation outlined in USGS QR-90-3 was delayed because of manpower requirements at the Hamdah and An Najadi prospects. A reevaluation is now planned for the Meshaheed area that will include the following:

- Conduct a preliminary evaluation of the seven prospects to establish priorities for future work, if warranted.
- Compile existing geologic and geochemical data.
- Submit a written report by 10/1993.

SCHEDULE

Start Date:	January 1993
Expected Task Completion Date:	October 1, 1993
Anticipated Report Transmittal Date:	October 1, 1993

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Work during this quarter consisted of geologic mapping, analytical work, compilation, and report writing. The mapping was conducted over a five-day period and covered the Meshaheed Pluton Southeast and Meshaheed Pluton West/Southwest grids at a scale of 1:500. Analyses of the 230 trench samples and 27 grab samples collected last quarter were completed. The best trench results from the Pluton West/Southwest prospect were in TR-7, which contained 1.5 ppm Au over 6 m. The best trench results from the Pluton Southeast prospect were in TR-2, which contained 0.73 ppm

over 22 m. Mapping indicated that these two intervals were in Murdama-group hornfels, which is broken by low-angle hematitic shears containing minor amounts of quartz.

TASK 4.2.4.2.03 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■	■										
Library Studies												
Site Survey		■			■	■						
Field Mapping										■		
Field Sampling					■	■				■		
Geophysics												
Drill/Trenching					■	■						
Lab Analyses						■	■	■	■	■		
Data Compilation							■	■	■	■		
Report Writing							■	■		■	■	
Technical Review												

4.2.4.2.04 Wadi Sha'bah NE (MODS 04234) and Wadi Sha'bah E (MODS 04235) -- H.W. Schull and Abdullah Al-Eissa

FOREWORD

The Wadi Sha'bah project area is about 10 km². It is located about 15 km northwest of the USGS An Najadi project area and about four kilometers west of Jabal Rihayl. The Wadi Sha'bah project area covers two gold quartz ancient mining sites, about two kilometers apart, each about 0.5 x 0.5 km in size. The gold mineralization

is Sukhaybarat-type, with gently dip-ping, lenticular veins of coarse crystalline quartz occurring in Murdama group sediments and Idah-type granodiorite.

Exploration started in September 1992. The aim is to define the near-surface extent and mode of occurrence of the gold mineralization in the ancient workings.

SCOPE AND OBJECTIVE

Tasks will be to prepare:

- Descriptions of mineralization and host rocks.
- 1:1,000- and 1:5,000-scales geologic maps.
- 1:500-scale drill-hole logs and trench cross sections.

- Estimations of grade and tonnage, where appropriate.
- Summary report by 07/1414 (01/1994).

SCHEDULE

Start Date:	1991
Expected Task Completion Date:	December 1993
Anticipated Report Transmittal Date:	Summary report-January 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Data compilation and report preparation continued through the third quarter.

Grid-type bedrock sampling over the poorly exposed dioritic rocks is recommended for Wadi Sha'bah East to search for diorite-hosted grain-disseminated gold mineralization. There are four zones of flat to low-angle bull-quartz veining recommended for further drill exploration.

TASK 4.2.4.2.04 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation												
Library Studies												
Site Survey												
Field Mapping	■ ■ ■ ■	■ ■ ■ ■										
Field Sampling	■ ■ ■ ■	■ ■ ■ ■										
Geophysics												
Drilling		■ ■ ■ ■	■ ■ ■ ■									
Lab Analyses	■ ■ ■ ■	■ ■ ■ ■		■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■						
Data Compilation			■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■		
Report Writing							■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■			
Technical Review												

4.2.6 EXPLORATION AND ASSESSMENT OF PHOSPHATE

4.2.6.2.01 Sirhan - Turayf Region -- M. Al Malki, A. Al Farasani, and O. Mourabet

FOREWORD

Discovery of new phosphate localities in northern Saudi Arabia suggests that the exploration of the region is still in its early stages. The potential for development of the many phosphate resource areas remains unanswered. Ore characterization is needed in significant areas to better describe the mineralogy, depositional aspects,

and processibility of phosphate rock. Regional mapping, stratigraphic studies, sub-surface drilling and correlation of the various phosphate units is required to evaluate the region.

Note: Subproject 4.1.1.2.02 is combined with this subproject.

SCOPE AND OBJECTIVE

- Geologic mapping of Cretaceous-Tertiary rocks of the Al Jalamid to Al Jauf region.
- Stratigraphic drilling to correlate mapped units with formations and members of Turayf group.
- Assess the known phosphate deposits in the Al Jauf area.
- Establish basic study criteria and complete documentation and reference files.
- Monitor water wells, correlate Devonian stratigraphy between the three 1992 test wells and the EW-8 well.
- Establish a computerized reserve data base.
- Provide summary report by 07/1415 (12/1994).

SCHEDULE

Start Date:	1991
Expected Task Completion Date:	December 1994
Anticipated Report Transmittal Date:	Summary report-January 1994

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NA
f) Editing in progress	NA
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

Progress under this project during the third quarter was minimal as a result of extensive mandatory leave requirements for the three principal project team members. However, the electronic data logger continued to be monitored during the quarter.

S.M.Dini's mapping work in phosphate-bearing formations in the Ash Shuwayhitiyah (30D) quadrangle, which has a direct bearing on this project, is reported under subproject 4.1.1.2. 01.

As reported in the second quarterly report, the 483 samples obtained during the stratigraphic drilling program were sent to the DGMR/USGS Analytical Laboratory in Jeddah. The results were received by Dini during the third quarter, yielding data that will further refine understanding of the boundaries of phosphate-bearing units in the Sirhan-Turayf basin.

TASK 4.2.6.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation	■■■■	■■■■										
Field Mapping									■■			
Geophysics												
Drilling					■■							
Lab. Analyses						■■■■						
Data Compilation												
Study Documentation			■■■■	■■■■	■■■■	■■■■						
Monitor Wells	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■	■■■■			
Data Analysis												
Sample Storage												
Report Writing												

4.3 MINING DEVELOPMENT

4.3.1 EVALUATION OF AL JALAMID PHOSPHATE DEPOSIT

4.3.1.2.02 Regional Assessment of Phosphate -- A. Al Khattabi, S. Dini, and A.

Al Farasani

FOREWORD

It is important for areas adjacent to the Al Jalamid feasibility study to be examined as extensions for

phosphate development.

SCOPE AND OBJECTIVES

The main objectives in 1993 are:

- Complete P₂O₅ analyses on exploration drill hole samples from the area adjacent to the Al Jalamid feasibility study area.
- Regional geologic synthesis of the Al Jalamid and

surrounding area in order to apply a new occurrence model of phosphorite deposits.

- A summary report will be completed by 02/1414 (08/1993).

SCHEDULE

Start Date:	January 1990
Expected Task Completion Date:	March 1993
Anticipated Report Transmittal Date:	September 1993

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NA
f) Editing in progress	NA
g) Completed	YES
Delays:	None

QUARTERLY WORK SUMMARY

The report of the regional assessment of the entire Al Jalamid area was completed at the end of this quarter, and will be sent to TRU in the fourth quarter, following technical review. The measured reserves of the Al Jalamid area were calculated at 400 MT including the Feasibility Study area, plus another 363 MT of phosphate ore of high MgO content was calculated as indicated resources in the surrounding areas.

Anwar Al Farasani will participate in a round of executive Promotional Seminars to be held in Toronto and Vancouver, Canada in early November 1993. The objective of the seminars will be to introduce potential Canadian investors to mineral-resource opportunities in the Kingdom.

Farasani's talk will be given under the title of *Current Investment Opportunities (The Case of Phosphate)*.

TASK 4.3.1.2.02 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chemical Analysis	■ ■ ■ ■											
Data Compilation	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■								
Reserve Calculations		■ ■		■ ■		■ ■	■ ■ ■ ■					
Report Writing							■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■			
Technical Review												

4.3.6 EVALUATION OF GHURAYYAH RARE METAL DEPOSIT

4.3.6.2.01 Appraisal of Previous Work and Recommendations -- P.R.

Johnson, A. Jastaniah, O. Mourabet, M. Al-Malki, W. Attar, and K. Alfi (BRGM)

FOREWORD

Ghurayyah is a large (440 million tonnes) low-grade rare-metal deposit (0.75 percent Zr, 0.25 percent Cb-Ta, 0.0115 percent U, 0.105 percent Y, 0.025 percent REE, 0.02 percent Sn), which represents the largest resource of these commodities known in Saudi Arabia. The deposit

is easily accessible and potentially easily mined. However, the adequacy of previous exploration has been questioned. The deposit was last evaluated in the late 1970s-early 1980s. A new evaluation is warranted, taking into account current market conditions.

SCOPE AND OBJECTIVES

- Evaluate previous exploration and drilling results and adequacy.
- Evaluate results of previous metallurgical test work.
- Evaluate scope and recommendations of previous reviews.
- Review current and projected world-wide supply and prices of relevant commodities.
- Submit evaluation report, making recommendations, by 03/1414 (09/1993).

SCHEDULE

Start Date:	March 1993
Expected Task Completion Date:	December 1993
Anticipated Report Transmittal Date:	Summary report-December 1993

PROGRESS

Status: a) In progress	YES
b) Delayed	NO
c) Abandoned	NO
d) Reinstated	NA
e) Technical review	NO
f) Editing in progress	NO
g) Completed	NO
Delays:	None

QUARTERLY WORK SUMMARY

During the quarter, variograms were made of existing analytical data for surface samples that had been collected from exposed parts of the Ghurayyah granite stock during previous exploration work. The data were obtained from composites made from 2,594 individual rock-chip samples. Each sample was a composite of 20 to 30 individual samples. Variograms done on the results indicate extreme variability between the analytical results of the composite samples, which means either that the granite stock is naturally heterogeneous, or that the sample density was too low. Whichever the case, the results of the variogram study suggest that the existing estimate of average grade is unreliable and invalidates the estimate of contained rare metals. The existing reports show that

drill-core samples were also composited for analytic purposes by grouping 8 to 9 individual samples to represent 24 to 27 m of core. Individual samples, representing shorter intersections, were not analyzed. Variograms of drill-core data have not been made because the small population of data would make the exercise unreliable.

During the coming quarter, an attempt will be made to locate and analyze the original individual surface samples, so as to compare analytical results of individual samples against the results of composite samples, and thereby characterize the degree of natural variability within the granite stock. Depending on the quality of remaining drill core, the drill holes will be relogged, sampled by spectrometer for equivalent U, K, and Th, and re-sampled for chemical analysis. Data for rare-metal production and prices elsewhere in the world will be collected, and world-wide market projections will be made, thereby providing basic economic information for the appraisal.

TASK 4.3.6.2.01 PROGRESSION CHART -- Fiscal Year 1993

	First Quarter			Second Quarter			Third Quarter			Fourth Quarter		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task Preparation			■ ■									
Library Studies			■ ■		■ ■							
Borehole Logging												
Petrophysics Study												
Data Compilation			■ ■	■ ■	■ ■			■	■			
Field Surveys					■							
Data Reduction												
Report Writing												
Technical Review												

5. SUPPORT SERVICES

5.1 ANALYTICAL AND GEOPHYSICAL LABORATORIES

5.1.1 ANALYTICAL LABORATORIES

5.1.1.2.01 Analytical Laboratory

FOREWORD

Programs of mineral exploration and geologic mapping require chemical analyses in order to determine the composition of rocks and minerals examined. Analyses help delineate metallic and nonmetallic mineral targets

that are of economic significance. The need for analytical results is on-going and requires facilities and personnel for sample preparation and chemical analyses that can respond quickly to program requests.

SCOPE AND OBJECTIVES:

- The facility will continue to support both USGS and DGMR operations.
- Establish and strictly maintain a system of allocating priorities for different types of analytical work.
- Maintain inventory of sufficient chemicals and glassware.
- Selectively replace worn out equipment and improve working environment of the crushing room, storage areas, and chemical laboratory.
- Store samples and pulps.
- Operate under USGS standards for procedures at crushing facility and in the various chemical sections (AA, Wet laboratory, Spectrographic).
- Maintain the annual capacity to run and complete at least 15,000 rock samples per year and to run from 1 to 30 determinations on each sample.
- Maintain fire-assay laboratory for the determination of gold in rocks.
- Maintain an Induction Coupled Plasma (ICP) section for the rapid quantitative determination of major rock forming and trace elements.
- Maintain a system for quality control by running duplicate samples, international and/or local standards, and/or external audit analysis, as may be required.

SCHEDULE AND PROGRESS

Status: Ongoing support
Delays: None

QUARTERLY WORK SUMMARY

The following analytical determinations were made in the DGMR/USGS Analytical Laboratory during the third quarter, 1993.

Month	A.A.	Wet Lab.	XRF	Spec.	ICP	F-A	Cyan.	Total determ. for Third Quarter
July	2,460	1,032	0	0	0	1,348	0	4,840
August	1,155	510	0	0	3,324	40	0	5,029
September	5	0	0	0	222	113	0	340
Totals	3,620	1,542	0	0	3,546	1,501	0	10,209

Crushing Operation

No. of samples on backlog, beginning of quarter:	137
No. of samples received for the quarter:	2,469
No. of samples completed for the quarter:	2,590
No. of samples on backlog at the end of quarter:	16

Analytical Laboratory

No. of samples on backlog, beginning of quarter:	1,636
No. of samples received for the quarter:	1,276
No. of samples completed for the quarter:	2,912
No. of samples on backlog at the end of quarter:	0

ICP mass spectrometer

At the end of the quarter, the Analytical Laboratory was pleased to receive the new ICP mass spectrometer. The equipment will be installed early in the fourth quarter, by A. Davies, of Fisons Instruments of Manchester, UK. The advantage of the ICPMS over most other methods of analysis is its extremely high sensitivity for isotopic multi-element detection of trace elements. Detection limits of most elements in aqueous solutions are routinely in the low parts per trillion range.

5.1.2 GEOPHYSICAL LABORATORY

5.1.2.2.01 Geophysical Laboratory

FOREWORD

An efficient and systematic mineral exploration program is strongly dependent upon high-quality, dependable, and timely geophysical surveys to help guide the project geologist. The Missions depend on geophysical surveys to guide the location and planning of drill holes, geologic mapping and geochemical sampling. Research in applied geophysical methods has the potential to yield considerable future benefits.

With the growing importance of geohazards investigations in the Kingdom, it is important to utilize geophysical techniques to investigate subsurface conditions that give rise to ground-subsidence cracks, saline-water invasion, naturally-occurring toxic waste

problems, landslides, and hidden cavities.

Electronic repair and maintenance capability are extremely important, as is the acquisition of modern geophysical and telemetry instruments. Measurements of rock properties are sometimes required to ensure statistical validity of geophysical interpretations.

[NOTE: This project includes elements of subprojects from 1412/1992, including 5.1.2.2.01 and 4.3.1.2.03, plus added elements to reflect and address the added responsibilities of the newly combined and expanded geophysical sections of DGMR, USGS, and BRGM.

SCOPE AND OBJECTIVES

- Support and participate in mineral exploration and geohazards programs within DGMR, USGS, and BRGM.
- Organize, plan, and coordinate field work and reports with DGMR, USGS, and BRGM geologists, managers, and editors.
- Conduct refraction and reflection seismic, resistivity, induced polarization, electromagnetic, audio-frequency magnetotelluric, radiometric, gravity and microgravity, magnetometer, ground-penetrating radar (GPR), and global positioning system (GPS) field surveys.
- Perform laboratory measurements of bulk and grain density, porosity, magnetic permeability and susceptibility, electrical resistivity, and induced polarization as necessary.
- Perform computer analysis and modeling.
- Acquire and improve modern software packages for modeling and analysis.
- Correlate natural radioactivity with economic deposits where possible.
- Determine degree of incompetence (beneficiation) of buried phosphate with particular attention to degree of weathering under wadis.
- Make preliminary estimates of phosphate content from gamma-ray logs integrated over the depth of the holes.
- Develop a systematic method for detection of cavities in karst regions, as equipment and budgets permit.
- Repair, maintain, and acquire the necessary electronics instruments: including seismic recorders, seismometer lines, SLINGRAM, TURAM, fluxgate magnetometers, DC chargers, radios, and oscilloscopes.
- Perform paleomagnetic measurements when warranted.

SCHEDULE AND PROGRESS

Status:

Ongoing support

Delays:

None

QUARTERLY WORK SUMMARY

Geophysical Laboratory

Routine maintenance and some repairs were carried out on field geophysical equipment by Leony Techico during the report period. The Genie electromagnetic profiling system received new

rechargeable batteries and will be used shortly in a geohazards application down drainage from the solid-waste landfill east of Jeddah. Two new 486 computers were received; one will be used for heavy electrical geophysical modeling, the other for seismic data analysis. A 386 computer, no longer under warranty, had a failed motherboard; however, a new motherboard was installed in-house more efficiently and at lower cost than shipping the units out to another country for repairs. A significant amount of time was spent testing communications between computers in Jeddah and the USGS National Center (Reston), all part of an extended effort to establish an E-Mail link to the Internet.

Under the direction of Maher Bazzari, the MGX logger was further tested, and new software was installed. A planned August field trip was canceled at the last moment at the recommendation of the field geologist due to extremely high temperatures in the field, and lack of an operating field camp. This logging effort is now scheduled for early in the fourth quarter, and will operate out of Al Jawf, with a staff of four geophysicists.

Work on cavity detection remains suspended pending the acquisition of a new digital reflection seismic unit and a Ground-Probing Radar (GPR) unit. Both units have been included in a contract between DGMR and ARGAS. The seismic unit, and more particularly, the GPR unit, will be useful in many additional geohazards applications.

Geophysics archives and datasets

Over the years, the Mission geophysics section has amassed a large amount of archival data. During the quarter Saeed Al-Ghamdi began an inventory of all data and maps in our possession with the goal of building a geophysical database that would allow us efficiently to determine all previous work that was done in any part of the Kingdom.

In addition to the archival database, a large magnetic dataset for almost the entire Kingdom was assembled by Nimr Arab, using USGS and Saudi Aramco data supplied by Aramco geophysicists. Dr. Arab also continued processing data from the 28,000 gravity stations covering the eastern coastal margins of the Red Sea obtained recently from Saudi Aramco.

Geophysical field services

The DGMR/USGS Geophysics Section began an ambitious field program during the third quarter of 1993. This program included at least 17 field trips, spread out over the third and fourth quarters. Field measurements have already been carried out at a number of sites, primarily to provide geophysical support to BRGM, DGMR, and USGS exploration geologists, but also to provide support for the growing USGS Geohazards Section. Despite extensive mandatory leave time taken by nearly all 17 members of the Geophysics Section, work was carried out in the following areas:

Al-Mohseniyah: Several color plates of magnetic and VLF data were replotted at the request of the BRGM project geologist. The project geologist provided core samples of unweathered Murdama Group metasediments, and Nimr Arab is beginning the final modeling of the magnetic data. Ash-Shiaila VLF data will also be plotted at the BRGM compilation scale of 1:2,500.

Rabathan: Gravity data acquired during the second quarter were processed and plotted, then delivered to the BRGM project geologist. This project has been put on temporary hold pending an extended effort at Jabal Shayban.

Yanbu (Buqariyah): A 6-man Geophysics Section team under the direction of Ahmed Zamzami worked for two weeks at Buqariyah, the large BRGM prospect near Yanbu, to carry out a series of experimental Vertical Electrical Soundings (Schlumberger type). The objective is to determine whether the altered rock in this apparent epithermal deposit could be distinguished from the underlying basement. Parameters obtained from the experimental work will be used in a second, production-phase, Schlumberger sounding effort to be carried out during the fourth quarter. A visiting BRGM geophysicist (Jean-Marc Mieke) visited the field site and offered his own observations and suggestions.

Jabal Shayban: ARGAS geophysical data acquired in the Jabal Shayban area in the mid-1970s were reviewed and recompiled at 1:2,000 scale. These older surveys included magnetic, electromagnetic, and IP/resistivity data. A three-man geophysics section team under the direction of Mabrouk Basahel spent several weeks working in extremely rugged terrain to expand a high-resolution magnetic survey at this DGMR/BRGM prospect north of Jeddah. This additional effort is being carried out at the request of the BRGM technical manager to determine if alteration can be identified at depth from magnetic data. Several interesting, apparently superficial magnetic anomalies of high amplitude but narrow spatial range were encountered, and fill-in stations were acquired to assess them further (fig. 10). These newer data will be integrated with the older data set.

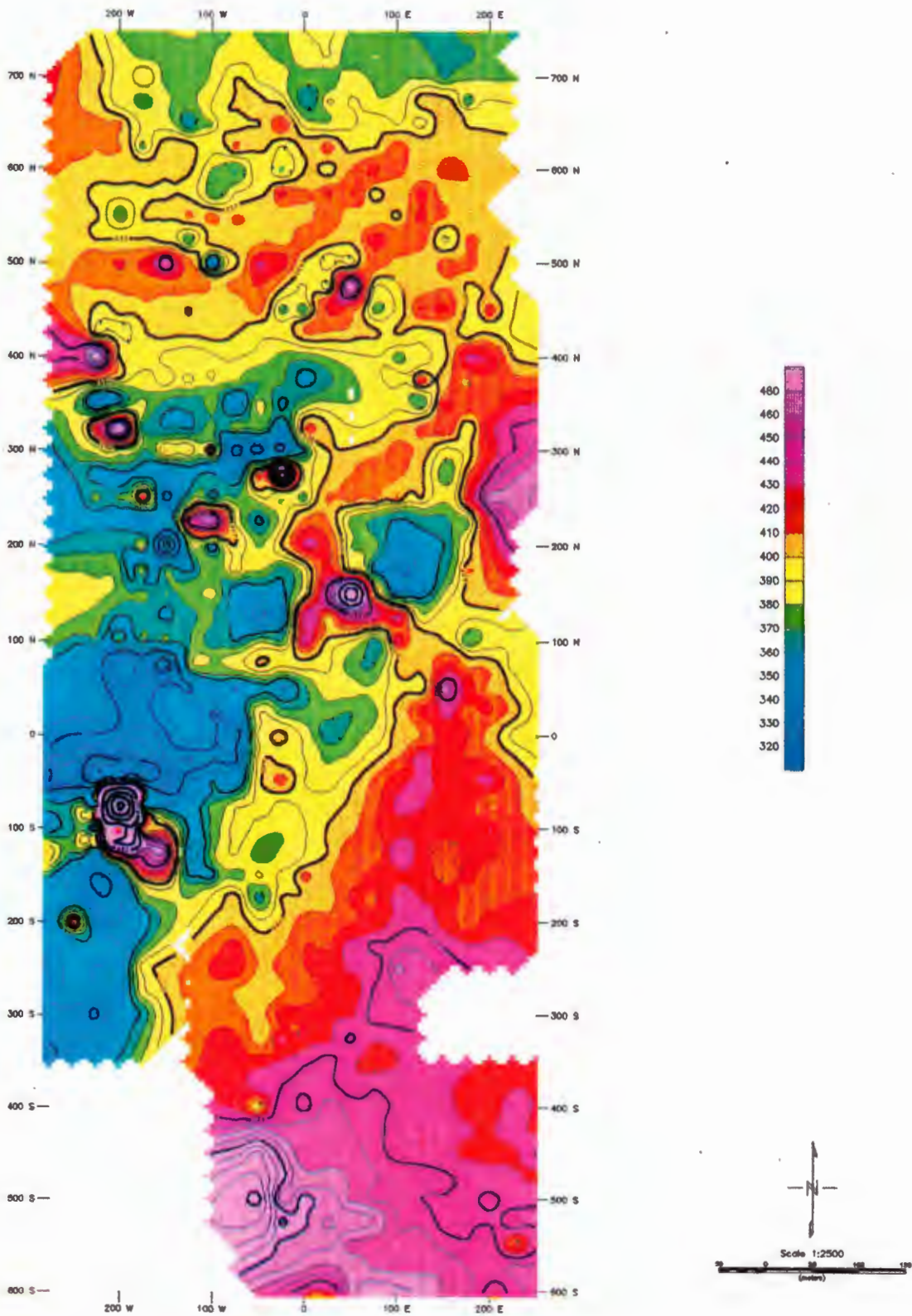


Figure 10. The total magnetic-anomaly contour map of the Jabal Shayban prospect.

5.2 PETROLOGIC AND MINERALOGIC LABORATORIES

5.2.1 PETROLOGIC AND MINERALOGIC LABORATORIES

5.2.1.2.01 Petrologic and Mineralogic Laboratory

FOREWORD

The petrologic and mineralogic laboratory is a centralized facility for USGS, BRGM, and DGMR. Geoscientists require petrologic and mineralogic support for the proper preparation of samples for detailed study. Specifically, they require support in the preparation of rocks, minerals, and ores in thin, slab, and polished

sections; they require support in slab and thin-section staining, mineral separation, X-ray diffraction, scanning-electron microscope analyses, and various analyses for size, shape, composition and other characteristics of mineral grains in geologic samples. Other laboratory preparation and analyses may be requested as needed.

SCOPE AND OBJECTIVES

- Maintain and operate the existing petrologic and mineralogic laboratory.
- Maintain the capacity of prepare as many as 2500 thin sections and 2500 polished sections per year.
- Undertake X-ray diffraction.
- Prepare samples for scanning-electron microscope

analyses.

- Maintain capacity to run as many as 1500 samples per year for rock and mineral identification.
- Maintain capability to run as many as 1000 heavy mineral separations per year.

SCHEDULE AND PROGRESS

Status:

Ongoing support

Delays:

None

QUARTERLY WORK SUMMARY

During the third quarter of 1993, work was completed on the expansion of the laboratory space. The drum storage area directly across from the current laboratory was converted into additional space for the Knelson concentrators, gold hounds, and Wilfley table operations, and is now operational. Thirty samples from Murayjib were processed with the gold hounds. The results were satisfactory with gold being observed in many of the samples.

Exhaust hoods and fans are being installed in the area of the crushing and grinding machines. When this is complete, the area will be a much safer place to work. Most of the fine airborne dust particles will be expelled by the hoods.

Room 109 in the Laboratory is being converted from a spare parts storage area to an optical microscope room for the examination of thin sections. The spare parts are being moved to room 118.

Nearly thirty DGMR gemstone mineral research samples of volcanic origin were processed. The samples were processed using the Wilfley table, heavy liquids, and Frantz isodynamic separator. The samples were examined optically and by XRD analysis. Traces of diamond are suspected. Further work is required for positive confirmation.

Laboratory output for the third quarter is shown in the following table:

PROCESS	MONTHLY PRODUCTION				YTD Cum. Total	SOURCE OF SAMPLES		RESULTING TOTAL	
	July	Aug	Sept	Total		From previous backlog	Present Quarter Submittals	Samples Processed	Sample Backlog
Thin Section									
<i>Standard</i>	58	16	16	90	420	14	76	90	0
<i>Polished</i>	54	2	68	124	316	12	112	124	0
<i>Stained</i>	29	0	3	32	270	29	3	32	0
<i>Doubly polished & polished mount</i>	17	0	0	17	41	8	9	17	0
<i>subtotals</i>	158	18	87	263	1047	63	200	263	0
Slab									
<i>Stained</i>	0	0	21	21	105	0	21	21	0
<i>Cut/Grind</i>	170	1	0	171	809	0	171	171	0
<i>Polished</i>	154	1	0	155	606	0	155	155	0
<i>subtotals</i>	324	2	21	347	1520	0	347	347	0
Modal Analysis	0	0	0	0	0	0	0	0	0
Mineral Separation	419	240	147	806	5136	145	80	224	1
X-ray Diffraction Analysis	44	155	96	295	1227	0	139	139	0
Rock Fusion	0	0	0	0	4	0	0	0	0
Totals	945	415	351	1711	8934	208	766	973	1

YTD = Year To Date

Production by the laboratory during the third quarter, 1993, by agency, for samples and jobs submitted was:

SUBMISSIONS BY SAMPLE

AGENCY	PREVIOUS BACKLOG	NO. OF SAMPLES RECEIVED	NO. OF SAMPLES COMPLETED	BACKLOG OF SAMPLES
DGMR	46	171	217	0
USGS	66	162	227	1
BRGM	30	161	191	0
Total	142	494	635	1

SUBMISSIONS BY JOB

AGENCY	PREVIOUS BACKLOG	NO. OF JOBS RECEIVED	NO. OF JOBS COMPLETED	BACKLOG OF JOBS
DGMR	84	343	427	0
USGS	94	260	353	1
BRGM	30	163	193	0
Total	208	766	973	1

5.3 REMOTE SENSING SERVICES

5.3.1 REMOTE SENSING -- J. Wynn (Acting), K. Saib, and A. Kurayyim

FOREWORD

Spectral data, remotely obtained by sensors mounted in aircraft or satellites, provide unique information about the composition of rocks and other earth materials on the Earth's surface. Image processing and interpretation of the data provide information about rocks and mineralization that greatly augments information

obtained by ground surveys alone. A state-of-the-art remote sensing facility is needed to apply image processing of remotely sensed multispectral data to the resolution of problems in mineral exploration, geohazards, and geologic mapping.

SCOPE AND OBJECTIVES:

- Maintain the image processing facility and remote sensing image files.
- Develop a state-of-the-art stand-alone image processing system with in-house hard copy capability
- Acquire LANDSAT, Thematic Mapper, SPOT, and aircraft multichannel spectrometer spectral images
- in computer-compatible tapes as needed.
- Generate enhanced images of new field work areas at start of each field season.
- Acquaint DGMR and Mission scientists with remote sensing applications to mapping and mineral exploration.

SCHEDULE AND PROGRESS

Status:	Ongoing support
Delays:	None

QUARTERLY WORK SUMMARY

Center for Remote Sensing

There has been tremendous forward movement in remote sensing during the third quarter, presided over by Khalid Saib. New minicomputers were purchased for the Mission-based Center for Remote Sensing (CRS), which will give the section the potential to be a first-rate remote sensing center.

A Vax-4200 computer system was purchased by DGMR/USGS Jeddah to allow the CRS to process different kinds of digital imagery. This computer system also includes a Q-bus expansion enclosure box, an IVAS image display system with a 19-inch high-resolution color monitor, a DEC workstation with a SCSI interface controller, 2-gigabyte external disk drives with SCSI interface controller, 2 Sony erasable optical disk drives, an 8-mm helical-scan tape drive, CD-ROM drive, two 6250-bpi 9-track tape drives, an 8-line network terminal server, four VT-420 terminals, and a DEC LN-06 laser printer. We anticipate the installation of a CD-ROM writer system to allow us to safely archive the very large amounts of imagery data that we already have acquired, free of the time limits imposed by tape-media storage.

The DIPIX imaging system ARIES III was moved from the VAX-6310 in the DGMR computer center to the VAX-4200 in the USGS-CRS. The ARIES II was left in the DGMR/BRGM computer center because, after discussions with the present manufacturers of the DIPIX system, it was determined that our older ARIES II system could not be interfaced to the 22-bit VAX-4200 Q-

bus system because it is based on an 18-bit architecture. The QCR film recorder has now been interfaced to the ARIES III.

The Open-VMS version 5.5-2 operating system, PICS (Planetary Image Cartography System) software, and ARIES (Image Analysis System) software were installed by Mr. Chuck Bowers (USGS-Flagstaff, Arizona) while on TDY in Jeddah; all systems were fully tested and operational by the first week of August.

During the hardware installation, selected remote sensing personnel (Khalid Saib, Suliman Safdar, and Hamad Al Sheheween) were trained by Bowers in techniques for testing and running system diagnostics. One of the 9-track tape drives was found to be damaged during shipment from the USA, so new parts were ordered and installation instructions were given by Bowers. The remote sensing team successfully replaced the damaged boards during the first week of September.

Maintenance and re-booting instructions were given to all CRS personnel. Training was given to Khalid Saib on systems administration, including the establishment of new user accounts, performing periodic system backups, checking disk drives, and other tasks. Bowers also gave all remote sensing personnel an introduction to PICS and ISIS-cube software systems.

Airborne imaging survey

During July and August final details were worked out for an ARGAS-DGMR (USGS technical management) airborne imaging survey contract and near the end of August the GER company shipped a 63-channel imaging scanner to Jeddah that is capable of working in the visible, near and middle infrared, and thermal infrared bands. Four GER staff arrived from GER headquarters in New York to install the equipment. The survey began over the Jeddah-Yanbu coastal corridor in the beginning of September.

Phil Davis, Senior Scientist and Chief of the USGS Branch of Astrogeology in Flagstaff, arrived in mid August, a week before the GER personnel arrived. Two weeks of instruction were given to remote-sensing personnel on the theory and use of fundamental image-processing algorithms. However, the computer systems were largely inoperable during the first week of GER operations because of problems with GER's computer hardware and software. In early September, with the system again working, remote sensing personnel were trained and participated in data verification and archival procedures for the airborne multispectral scanner.

However, problems with the airborne multispectral scanner started early and became very serious (many of the bands were not operational, including all of the thermal and all of the water bands, and many of the remaining bands were seriously noise-degraded). After two weeks of flying and a seeming lack of cooperation on the part of the contractor, the scanner system was grounded until it could be made fully operational by GER. This decision was made jointly by Mr. Sultan Shawly (ARGAS contract monitor), Mr. Ghazi Dairi (DGMR Representative at USGS), Dr. Jeff Wynn (USGS flight monitor), and Dr. Phil Davis (USGS technical advisor). GER sent an optical engineer and an electronic engineer to repair the problems, and two weeks of intensive repair efforts began in the Special Flights hangar at KAIA. Tremendous support was received from Special Flights pilots and managers during the earlier flying and during this repair effort.

During September most of CRS personnel were trained on the use of the GER field radiometer. Radiometer measurements were obtained at five field reference sites in support of the airborne scanner survey. Three field trips were taken by helicopters by Saib and Davis to the

reference sites for each of the airborne survey areas. Additional trips were made by most remote sensing personnel. There were three additional field trips to the reference site east of Thuwal that included most of the CRS personnel, during which most individuals used the radiometer at least once to obtain data.

5.4 PHOTOGRAPHIC SERVICES

5.4.1 PHOTOGRAPHIC LABORATORY

5.4.1.2.01 Photographic Laboratory

FOREWORD

A significant part of the base materials required by geologists, geophysicists, and topographers consists of camera-enlarged base maps, aerial photographs, and stereo-pairs of photographs. Scientists routinely use these materials to determine accurate locations and to

record field observations. High-quality images for presentations, displays, and for the remote-sensing facility commonly require reproduction and enlargement done by the photographic laboratory.

SCOPE AND OBJECTIVES

- Provide high-quality imagery, photography, and reproductions as requested.
- Provide routine procedures for the purchase of supplies and chemicals.
- Service, repair, and recalibrate the existing large-format camera.
- Renovate and repair the existing laboratory premises on a routine basis.
- Repair, and as necessary, replace, other essential plant equipment.
- Provide safe storage for photographic negatives and other materials.

SCHEDULE AND PROGRESS

Status:	Ongoing support
Delays:	None

QUARTERLY WORK SUMMARY

The Photographic Laboratory processed 86 requisitions representing 1,159 reproductions during the third quarter 1993.

The King Concept Image Maker II for developing color negative films and slides is still not repaired or replaced, and the Agfa process color paper print is out of order.

5.7 COMPUTER SERVICES AND DATABASES

5.7.1 COMPUTER SERVICES AND DATABASES

5.7.1.2.01 Computer Services

FOREWORD

Mineral exploration and modern techniques of geochemical surveying, geophysical interpretation, drill-core analysis, and deposit evaluation generate and utilize large amounts of numeric data. These data are

most effectively stored and manipulated by computers. The USGS also utilizes administrative and accounting computer programs to help manage and control its projects.

SCOPE AND OBJECTIVES

- Maintain and upgrade the existing computer facilities at the USGS.
- Maintain the Computer Users Committee to ensure cooperation among computer users and compatibility between computer systems and software.
- Fully utilize TECHBASE software for modeling ore reserves at An Najadi and Wadi Sha'bah gold prospects.
- Provide expertise and support in digitization of prospect maps, using GSMAP, and other software packages.

SCHEDULE AND PROGRESS

Status:	Ongoing support
Delays:	None

QUARTERLY WORK SUMMARY

During the third quarter of 1993, work was completed inputting, proofreading, and editing data for trench overburden, drill-hole, and trench bedrock samples for the An Najadi database. The percussion drill-hole lithologic data have been entered into TECHBASE and an overburden and bedrock estimation for gold was completed. Computer core logs of all drill holes were generated using TECHBASE. Statistical summaries for numbers of samples, mean, median, mode, standard deviation, variance, maximum, minimum, coefficient of variation, standard error, skewness, and kurtosis were generated for all the An Najadi data. Numerous histograms, cumulative frequency diagrams, plots, base maps, and semi-variograms were generated using TECHBASE. The final report, which will complement the An Najadi prospects report, will be completed by the end of the fourth quarter.

Wadi Sha'bah analytical data were entered into Lotus 123 spreadsheets. The drill hole and grab sample data entries are complete and the trench samples will be completed by the end of the fourth quarter.

Geohazards earthquake data were entered into TECHBASE. Plots was generated showing the location of the earthquakes plotted with a symbol that is proportional to the magnitude of the earthquake.

5.8 LIBRARY AND BIBLIOGRAPHIC SERVICES

5.8.1 LIBRARY AND BIBLIOGRAPHIC SERVICES

5.8.1.2.01 Library and Bibliographic Services

FOREWORD

DGMR and Mission technical staff benefit immeasurably with access to published geologic and other scientific reference sources. DGMR library facilities, housed primarily at the USGS Mission, should be fully consolidated, and arranged and expanded to better fill

the needs of the DGMR staff and work programs. As projects come to a close, the archival materials that were generated need to be organized and maintained in secure locations for future access by appropriate DGMR staff.

SCOPE AND OBJECTIVES

- Maintain a consolidated DGMR library facility at USGS.
- Establish a uniform, on-line cataloguing system for library holdings.
- Establish a computerized circulation system to track borrowed library materials.
- Establish an up-to-date on-line database of DGMR reports and publications.
- Establish appropriate workstations to allow user access to bibliographic and other databases in use at DGMR.
- Keep library current by acquiring appropriate new periodicals, books, and bibliographic databases.
- Keep the earth-science staff at DGMR and the

- Missions informed of new library acquisitions.
- Maintain technical report libraries at DGMR and BRGM.
 - Maintain close contact with the USGS National Center library in Reston, Virginia, so that our geoscientists can obtain off-prints and photocopies of articles needed for their projects.
 - Provide an annotated bibliography of DGMR publications, maps, and reports in bound form.
 - Maintain the DGMR, Riofinex, Seltrust, and Red Sea Commission archives.
 - Provide secure locations for all archival materials.
 - Establish computer-based inventories of archive datafiles.

SCHEDULE AND PROGRESS

Status: Ongoing support
Delays: None

QUARTERLY WORK SUMMARY

Routine library activities continued during the third quarter of the fiscal year 1993. Over 40 books on mineral economics, mineralogy, engineering geology, gold, and other fields in the geosciences were received, commonly at the request of USGS and DGMR personnel. Approximately one dozen requests were sent by FAX to the USGS National Center library in Reston, Virginia for photocopies of articles not available in the library. USGS stateside publications and many scientific journals continued to arrive in the library.

With the assistance and support of Peter Cadenas-Planas, the new Mission Procurement Officer, many 1994 journal subscriptions were purchased during the quarter. By making arrangements early, the library hopes to ensure that all issues will be received in a timely manner and without a break in delivery schedules.

After discussions with Dr. Mohammad Asa'ad Tawfiq, DGMR Assistant Deputy Minister for Survey and Exploration , it was agreed that the Mission would generate disk and hard-copy bibliographic citations and abstracts of all DGMR, USGS, BRGM, and Riofinex reports and maps that were issued from 1985 to the close of 1993. This dataset, which will be generated by USGS Mission staff attached to the library, would be released as a Bulletin in the DGMR Bulletin series. This dataset would be added to the Middle East GeoRef database currently in use at DGMR. However, instead of the older, disk-based version presently in use, the new bibliographic database would be issued in CD-Rom format, under the working title SAGA (Saudi Arabian Geoscience Abstracts).

5.9 REPORTS

5.9.1 TECHNICAL REPORTS UNIT

5.9.1.2.01 Technical Reports Unit (TRU)

FOREWORD

An important function of the DGMR and USGS is to record and disseminate information gathered during the course of mineral exploration and geologic survey activities. The basic types of publications issued by the DGMR and USGS consist of technical reports and data

files. These are intended for distribution within the geologic community of the DGMR, in order to rapidly disseminate the results of DGMR investigations. The Technical Reports Unit also prepares illustrations and slides that are used in displays and presentations.

SCOPE AND OBJECTIVES

- Maintain and expand Technical Reports Unit (TRU) facilities for the effective preparation of maps and reports to technical-report standards.
- Maintain drafting facilities for the preparation of maps and other diagrams.
- Maintain desk-top publishing capability, update hardware and software where appropriate.
- Maintain in-house reproduction facilities for small-sized maps and diagrams, and written text.
- Maintain capability to contract for large-sized or complex printing jobs.
- Review text and all illustrations for format and clarity for all reports.
- Assist DGMR in report review and production where possible.
- Assist geoscientists in obtaining base materials for map preparation.
- Liaise with authors at early stage for best preparation methods or reports and maps.
- Expand computer-graphics capabilities for figure- and plate-sized illustrations, utilizing both digitizing and scanning techniques.
- Establish video capabilities to include recording, editing, and finishing documentation of geoscience activities.

QUARTERLY WORK SUMMARY

During the third quarter, the Mission Technical Reports Unit completed the drafting and editing required to transmit two mineral belt reports, and a report on geochemical exploration in the Hamdah-Jabal Riah area. These documents were released in the DGMR Technical Reports series. Unit draftsmen were also engaged in completing review versions of plates for the large An Najadi prospect report, due at the end of the year, and in preparation of two 1:500,000-scale sheets of the Proterozoic geology of western Saudi Arabia. These map sheets will be released early in the fourth quarter. They are the first two of a suite of six geologic maps covering the Saudi Arabian Neoproterozoic Shield planned for transmittal by USGS.

Almost 3,200 copies were generated on the Canon color copier of which 43 percent was done on behalf of USGS Mission, 30 percent for BRGM and 27 per cent for DGMR.

The work of Mission TRU was enhanced by the arrival of Robert Fraser of the USGS Office of Scientific Publications (Reston) on TDY assignment in Jeddah from September 5 to September 24, 1993. Fraser's efforts were directed primarily to preparation of the Ash Shuwayhitiyah and Turayf-An Nabk quadrangle sheets for production in the DGMR Geoscience Map series. Fraser also assisted the TRU drafting team in the completion of plates for the upcoming An Najadi prospects technical report.

Reports:

The USGS Mission transmitted the following reports to DGMR during the third quarter of fiscal year 1993:

- U.S. Geological Survey, 1993, Quarterly progress report of the USGS Mission, Kingdom of Saudi Arabia, for the second quarter of the Fiscal Year 1993: Saudi Arabian Directorate General of Mineral Resources Quarterly Report USGS-QR-93-2, 79 p.
- Carten, R.B., 1993, Gold prospects of the Jabal Riah mineral belt, Kingdom of Saudi Arabia, and implications for regional and shield-wide mineral exploration: Saudi Arabian Directorate General of Mineral Resources Technical Report USGS-TR 92-10, 41 p., 1 appendix.
- Bosch, P.S., 1993, The Bi'r Hamadan mineral belt, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Technical Report USGS-TR-93-3, 61 p., 1 appendix.
- El Komi, M.B. and Carten, R.B., 1993, Reconnaissance wadi-sediment geochemical exploration: Hamdah-Jabal Riah gold district, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Technical Report USGS-TR-92-9, 36 p.
- Johnson, P.R., and Stewart, I.C.F., 1993, Magnetic anomalies and basement structure in central Arabia: Saudi Arabian Directorate General of Mineral Resources Open-File Report USGS-OF-93-5, 29 p.
- Johnson, P.R., Carten, R.B., and Jastaniah, A., 1993, Tabulation of previously published U-Pb, Rb-Sr, and Sm-Nd numerical age data for the Precambrian of northeast Africa and Arabia: Saudi Arabian Directorate General of Mineral Resources Open-File Report USGS-OF-93-1, 29 p.

5.10 PUBLICATIONS

5.10.1 PUBLICATIONS

5.10.1.2.01 Publications

FOREWORD

The Publications Department provides the essential functions of phototypesetting, cartography, printing, and distribution of maps, brochures, and reports for the

DGMR. The work is done to a high professional standard and should continue.

OBJECTIVES

- To disseminate nationally and internationally the results of major work programs dealing with mineral exploration and deposit evaluation.
- To publish maps, reports, and public information brochures about geologic matters in order to provide an efficient service to the scientific community.
- To distribute professional, durable materials to the scientific community.
- To work cooperatively with the technical reports units to make the best use of TRU and Publications' manpower and equipment.
- To provide facilities for phototypesetting and cartography in support of DGMR publications.
- To provide summaries of work for quarterly and annual reports.

QUARTERLY WORK SUMMARY

During the third quarter 1993, additional staff from the DGMR were temporarily transferred to the Publications Department to help in publishing DGMR technical reports. Dr. H. Rieke, DGMR text editor, left the DGMR on August 26, 1993. A total of 5 DGMR reports were edited, published, and distributed by Rieke during the quarter.

Since January 1993, the following Ministry reports were issued by the Publications Department on behalf of DGMR:

LeAnderson, J., Ikram, N., and Dahlawi, S., 1993, Difference between the three gold assay methods used by the DGMR and a re-evaluation of the Aqiq Ghamid, Jabal Baydan and Makkah Road Prospects and the Jabal Tharwah ultramafic complex: Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-TR-93-2, 53 p.

Al-Quorashi, H.E., Babakair, M.S., and Mulla, F.M., 1993, Mineralization of the Ad Duwwarah carbonated ultramafic rocks: Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-TR-93-4, 40 p.

Al-Quorashi, H.E., Babakair, M.S., and As-Sulaymani, K.L., 1993, Gold mineralization of the carbonated and highly altered ultramafic rocks in the Wadi Kamal area (24/37D): Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-TR-93-5, 22p.

Hanif, M.R., and Al-Thekair, M., 1993, Geology and geochemistry of the Wadi Sinan area. Jabal Radwa quadrangle (24/38A): Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-TR-93-6, 69 p.

DGMR Geologists, 1993, DGMR quarterly report for the first quarter of the fiscal year 1993: Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-QR-93-1, 39 p.

DGMR Geologists, 1993, DGMR quarterly report for the second quarter of the fiscal year 1993: Saudi Arabian Directorate General of Mineral Resources Technical Report DGMR-QR-93-2, 43 p.

Cartographic Section: The section processed 20 drafting and typesetting job requests.

Print Shop: The section processed 66 different job requests representing 45,334 items printed.

Distribution Section: The following publications were requested and distributed during the quarter 1993:

Items distributed:	No. copies
Arabian Peninsula maps (AP)	8
Bulletins	50
Geoscience Maps (GM)	733
Informational Circulars	27
M.R.A.	5
Professional Paper	3
Publications Lists 1991	18
Riofinex Reports	4
USGS Reports	35
TOTAL	883

5.11 LAND TRANSPORTATION

5.11.1 LAND TRANSPORTATION

5.11.1.2.01 Land Transportation (USGS)

FOREWORD

Given the difficult and often rugged terrain in which the DGMR operates, the DGMR must maintain a fleet of dependable, late-model vehicles to meet the need to transport men and equipment to the field. There is also

the need for a town fleet of vehicles to meet administrative requirements, and to link the various facilities of the DGMR in Jeddah.

OBJECTIVES

- Renovate and remodel the existing DGMR garage and workshop.
- Maintain procedures for the routine purchase of supplies.
- Maintain procedures for the purchase of new vehicles.
- Replace light-duty 4 wheel-drive vehicles that are over 6 years old, and heavy-duty trucks over 8 years old.
- Provide opportunities for on-the-job training for DGMR mechanics.
- Maintain a pool of drivers for field duties.
- Maintain a pool of drivers for town duties.
- Maintain a staff of mechanics for regular servicing and repair of field and town vehicles.

SCHEDULE AND PROGRESS

Status:	Ongoing support
Delays:	None

QUARTERLY WORK SUMMARY

During the quarter, Land Transportation supported five USGS field camps: Jabal Sayid, Al Madinah, Meshahed, Murayjib and Turayf, plus a "spike" camp in the Aqiq area.

With the start-up of the airborne remote sensing project, to be based near Jabal Sayid, a large number of Toyota Landcruisers and pickups were used to transport personnel, supplies and equipment from Jeddah to the work area in Jabal Sayid. Three diesel tankers were required for refueling Special Flights aircraft, and two water trucks were used to furnish the camp with a daily freshwater supply and to spray the airstrip on a daily basis.

Four Toyota Landcruiser Stationwagon and two Toyota Landcruiser pickups were purchased in support of field services during this quarter. Two Ford Pickup trucks were returned to DGMR's jurisdiction for surplus auction.

5.12 FIELD SERVICES

5.12.1 FIELD SERVICES

5.12.1.2.01 Field Services (USGS)

FOREWORD

In order to operate efficiently in the field, Mission scientists and ancillary staff require adequately provisioned camps, back-up services, and supplies.

These can be best provided for under a formally named and unified project.

OBJECTIVES

- Establish effective procedures for the purchase of field supplies and equipment.
- Maintain well-organized field stores in Jeddah.
- Maintain routine procedures for issuing field equipment and supplies to geologists and other staff embarking on field work.
- Maintain straightforward procedures for setting up and maintaining field camps and temporary bases for project work away from Jeddah.
- Maintain radio equipment for communication between Jeddah and field bases.
- Maintain land transportation in support of Mission operations.
- Liaise closely with Saudia Special Flight Services in order to provide air transportation needs in the field.
- Employ adequate numbers of field officers, field assistants, laborers, guards, cooks, and others, to man and manage field camps.

SCHEDULE AND PROGRESS

Status: Ongoing support
Delays: None

QUARTERLY WORK SUMMARY

During the quarter, field services personnel consisting of camp bosses, field drivers, cooks, diesel mechanics, carpenters and electricians provided continuous support to USGS field camps in Al Jalamid, Jabal Sayid, Murayjib, Meshaheed and Al Madinah.

Additional staff personnel were called upon to relocate field equipment and supplies from Meshaheed to a new camp location in Al Qubbah, near Al Wajh, and continuous support of the existing camp in Murayjib.

Special Flights Services continue to support all USGS Mission camps with fixed-wing aircraft and helicopters. Special emphasis was placed upon the requirements of remote sensing project now underway in Jabal Sayid.

APPENDIX 1. Staff (in man months) assigned to the USGS Saudi Arabian Mission during the third quarter of the Fiscal Year 1993.

		Jul	Aug	Sep
1.	MANAGEMENT AND ADMINISTRATION			
1.11	TECHNICAL ADMINISTRATION			
	Sargent, K.A. - Chief of Mission (COM)	1.0	1.0	1.0
	Carten, R.B. - DCM, Scientific Affairs	1.0	1.0	0.3
	Leavitt, J.D. - Chief Geologist	1.0	1.0	1.0
1.12	NON-TECHNICAL ADMINISTRATION			
	DeMeglio, G.V. - DCM for Administration	1.0	1.0	1.0
	Wood, B.M. - Budget & Fiscal Officer	1.0	1.0	1.0
	Saifuddin, F.H.* - GSO Officer	1.0	1.0	1.0
	Togans, P.W. - Property Manager	0.3	0.3	0.3
	Cadenas, P.P. - Procurement Officer	1.0	1.0	1.0
	VandenHeuvel, T.J. - Contract Officer	1.0	1.0	1.0
	Abdulmajeed, A.R. * - Sr. Administrative Officer.	1.0	1.0	1.0
	Abuzinadah, A.A. * - Deputy Procurement Officer	1.0	1.0	1.0
	Obeid, A.A. * - Chief Accountant	1.0	1.0	1.0
	Shams, A.M. * - Personnel	1.0	1.0	1.0
	Salama, E.A. * - Finance Officer	1.0	1.0	1.0
4.	TECHNICAL PROGRAM			
4.1	GEOLOGICAL SERVICES TO THE COMMUNITY			
	Schmidt, P.W. - Geologist	1.0	1.0	1.0
	Swolfs, H.S. - Geologist	1.0	1.0	1.0
	Wynn, J.C. - Geophysicist	1.0	1.0	1.0
	Bazzari, M.A. * - Geophysicist	0.5	0.5	0.5
	Hashem, H. * - Geologist	1.0	1.0	1.0
	Showail, A. * - Geophysicist	1.0	1.0	1.0
4.2	MINERAL EXPLORATION			
	Albino, G.V. - Geologist	0.00	0.7	1.0
	Bosch, P.S. - Geologist	0.3	0.0	0.0
	Christian, R.C. - Geologist	0.2	0.2	0.2
	Johnson, P.R. - Geologist	1.0	1.0	1.0
	Lewis, R.S. - Geologist	1.0	1.0	1.0
	Schull, H.W. - Geologist	1.0	1.0	1.0
	Walker, B.M. - Geologist	1.0	1.0	0.8
	El Komi, M.B. * - Geologist	1.0	1.0	1.0
	Jannadi, E.H. * - Geologist	1.0	1.0	1.0
	Hussein, M.A. * - Geologist	1.0	1.0	1.0
	Bazzari, M.A. * - Geophysicist	0.5	0.5	0.5
	Al Yazidi, S.* - Geologist	1.0	1.0	1.0
4.3	MINING DEVELOPMENT			
	Dini, S. * - Geologist	1.0	1.0	1.0
	Farasani, A.A. * - Geologist	1.0	1.0	1.0

APPENDIX 1. Staff assigned to the USGS Saudi Arabian Mission--Continued

		Jul	Aug	Sep
5.	SUPPORT SERVICES			
5.1	ANALYTICAL LABORATORIES			
	Aruscavage, P.J. - Chemist	1.0	1.0	1.0
5.2	PETROLOGIC AND MINERALOGIC LABORATORIES			
	Naqvi, M. * - Geologist	1.0	1.0	1.0
	Christian, R.P. - Geologist	0.2	0.2	0.2
5.3	REMOTE SENSING SERVICES			
	Khalid Saib - Remote Sensing Specialist	1.0	1.0	1.0
	Sheheween, H. * - Remote Sensing Specialist	1.0	1.0	1.0
	Bowers, C. (T) - Remote Sensing Specialist	0.3	0.4	0.0
	Davis, P. (T) - Remote Sensing Specialist	0.0	0.5	1.0
	Collins, R. (T) - Remote Sensing Specialist	0.0	0.2	1.0
	Bernstein, R. (T) - Remote Sensing Specialist	0.0	0.2	1.0
	Ruben, T. (T) - Remote Sensing Specialist	0.0	0.2	0.3
	Chang, H. (T) - Remote Sensing Specialist	0.0	0.0	0.3
	Westfield, M. (T) - Remote Sensing Specialist	0.0	0.0	0.3
	Stevens, R. (T) - Remote Sensing Specialist	0.0	0.0	0.2
5.4	PHOTOGRAPHIC SERVICES			
	Al Gahani, M.S.* - Sr. Photographer	1.0	1.0	1.0
5.6	TOPOGRAPHIC SURVEYING			
	Liban, Saeed * - Topographer	1.0	1.0	1.0
5.7	COMPUTER SERVICES AND DATABASES			
	Christian, R.P. - Geologist	0.6	0.6	0.6
5.8	LIBRARY AND BIBLIOGRAPHIC SERVICES			
	Vranas, G.J. - Archivist	0.1	0.1	0.1
	Abdul Baqi, H. * - Librarian	1.0	1.0	1.0
5.9	REPORTS			
	Vranas, G.J. - Chief, TRU	0.9	0.9	0.9
	Fraser, R. (T) - Map Editor	0.0	0.0	0.7
5.10	PUBLICATIONS			
	Hajraf, K.* - Chief, Publications	1.0	1.0	1.0
5.11	LAND TRANSPORTATION			
	Abdullah, Y. *	0.5	0.5	0.5
5.12	FIELD SERVICES			
	Togans, P.W. - Field Services Officer	0.7	0.7	0.7
	Abdullah, Y. * - Chief, Field Operations	0.5	0.5	0.5

TOTALS: Full-time man months: 130.7 Full-time man years: 10.89

* Local staff (T) Temporary duty (US) Working in United States (V) Visitor

APPENDIX 2. Summary of reports published by USGS Saudi Arabian Mission to date for the Tenth Extension Agreement.

1990 REPORTS

Report No.	Brief Title	Authors
USGS OF-10-9	Haql seismicity	Bazzari and others
USGS TR-07-4	Metallic mineral assessment--Aban al Ahmar	Kamilli and others
USGS TR-90-1	As Sarat volcanic field	duBray and others
USGS OF-09-8	Regional gravity, Aban al Ahmar	Kane and others
USGS QR-90-1	Quarterly Report	USGS
USGS QR-90-2	Quarterly Report	USGS
USGS QR-90-3	Quarterly Report	USGS
USGS QR-90-4	Quarterly Report	USGS (released in 1991)
USGS TR-91-1	Annual Report for 1990	USGS (released in 1991)

1991 REPORTS

USGS TR-91-1	Annual Report for 1990	USGS
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Progress Reports:

- Volcanoseismic hazard at Harrat Rahat--A Progress Report, by E. T. Endo
- Al Wajh Gold District--A Progress Report, by P.R. Johnson (Further work is recommended in southern Al Wajh gold district to define a mineral belt.)
- An Najadi-Wadi Ash Shu'bah area--A Progress Report, by P.R. Johnson. (Further work is recommended at An Najadi, Wadi Ash Shu'bah Northeast Prospect, and Wadi Ash Shu'bah East Prospect.)
- Hamdah Mineral Belt--A Progress Report, by R.B. Carten
- Jabal Riah Mineral Belt--A Progress Report, by R.B. Carten
- Bi'r Hamdan Mineral Belt--A Progress Report, by R.B. Carten
- Hamdah Gold Prospect--A Progress Report, by A.A. Bookstrom
- Al Jalamid Phosphate Deposit--A Progress Report, by J.J. Cape
- Regional assessment of phosphate resources--A Progress Report, by R.P. Sheldon

USGS OF-10-8	Aeromagnetics of the Precambrian Shield	Blank, Andreasen, and Johnson (Ed.)
USGS MF-2129	Geologic map of Harrat Hutaymah	Thornber
USGS DFR-91-1	Stoichiometry of phosphate minerals	Sheldon
USGS DFR-91-2	Drill patterns for phosphate resources	Sheldon
USGS DFR-91-3	Gravity profiles at Harrat Rahat	Showail and Khoja
USGS DFR-91-4	Reconnaissance, Al-Mudawwarah quad	Farasani and Dini
USGS DFR-91-5	Resource assessment--As Sanam and Wadi Al-Fayha	Farasani and others
USGS DFR-91-6	Phosphate exploration in Thaniyat and Sanam	Davis and others
USGS QR-91-1	Quarterly Report	USGS
USGS QR-91-2	Quarterly Report	USGS
USGS QR-91-3	Quarterly Report	USGS
USGS QR-91-4	Quarterly Report	USGS (released in 1992)
USGS TR-92-1	Annual Report for 1991	USGS (released in 1992)

**APPENDIX 2. Summary of reports published by the USGS Saudi Arabian Mission--
Continued**

1992 REPORTS (continued)

Report No.	Brief Title	Authors
USGS TR-92-1	Annual Report for 1991	USGS
<i>Progress Reports:</i>		
	• Geologic mapping in the Turayf basin--A Progress Report, by C.A. Wallace	
	• General assessment of geohazards--A Progress Report, by H.S. Swolfs	
	• Volcanoseismic hazard at Harrat Rahat--A Progress Report, by E.T. Endo	
	• Harrats Rahat and Khaybar gravity studies--A Progress Report, by C.H. Miller	
	• Prospecting for gold--A Progress Report, by P.R. Johnson	
	• Weathering history of western Saudi Arabia--A Progress Report, by P.R. Johnson	
	• Gold exploration in the Al Wajh district--A Progress Report, by P.R. Johnson	
	• Hamdah Mineral Belt--A Progress Report, by E.H. Jannadi	
	• Jabal Riah Mineral Belt--A Progress Report, by R.B. Carten	
	• Bi'r Hamdan Mineral Belt--A Progress Report, by P.S. Bosch	
	• Hamdah Gold Prospect--A Progress Report, by A.A. Bookstrom	
	• An Najadi Gold Prospect--A Progress Report, by B.M. Walker	
	• Meshahed Gold Prospect--A Progress Report, by B.M. Walker	
	• Al Jalamid Phosphate Deposit--A Progress Report, by J.J. Cape	
	• Regional assessment of phosphate resources--A Progress Report, by R.P. Sheldon	
USGS OF-92-1	Qualitative interpretation of aeromagnetic data	Johnson, and Vranas
USGS OF-92-2	List of interagency reports	Vranas
USGS OF-92-3	33 Gold occurrences	Bookstrom and White
USGS OF-92-4	Prospecting for gold	Johnson
USGS OF-92-5	Gravity Profiles, near Tabah	Kane and Showail
USGS OF-92-6	Petrology & geochemistry of alkaline volcanics, Hutaymah	Thornber
USGS OF-92-7	GPS survey, Harrat Rahat	Endo and others
USGS TR-92-2	Salma Caldera	Kellogg
USGS TR-92-3	DGMR/USGS chemistry laboratory analytical procedures	Aruscavage and Hakim
USGS TR-92-4	Hamdah gold prospect, estimation of gold resources	Christian and Bookstrom
USGS TR-92-5	Hamdah gold prospect, heap-leach processing	Albert and Carten
USGS TR-92-6	Hamdah gold prospect, exploration for gold	Bookstrom and others
USGS TR-92-7	Hamdah gold prospect, pilot heap-leach test	Cassiday and Carten
USGS TR-92-8	Hamdah gold prospect, models for estimation of gold	Christian and others
USGS DFR-92-1	Sukhaybarat mine	Johnson
USGS DFR-92-2	J. Shizm	Johnson and Jannadi
USGS QR-92-1	Quarterly Report	USGS
USGS QR-92-2	Quarterly Report	USGS
USGS QR-92-3	Quarterly Report	USGS
USGS QR-92-4	Quarterly Report	USGS (released in 1993)
USGS TR-93-1	Annual Report for 1992	USGS (released in 1993)

**APPENDIX 2. Summary of reports published by the USGS Saudi Arabian Mission--
Continued**

1992 REPORTS (continued)

Additional reports reviewed, edited, and processed by USGS TRU:

GM-123	Geologic map, Harrat Rahat Cenozoic lava field	Camp and Roobol
GM-131	Geologic map, Harrats Khaybar, Ithnayn, and Kura Cenozoic lava fields	Roobol and Camp
GM-132	Geologic map, Harrat Kishb Cenozoic lava field	Roobol and Camp
DGMR-TR-91-3	Geographic map, Harrat Rahat Cenozoic lava field	Camp and Roobol
DGMR-TR-91-4	Geographic map, Harrats Khaybar, Ithnayn, and Kura Cenozoic lava fields	Roobol and Camp
DGMR-TR-91-5	Geographic map, Harrat Kishb Cenozoic lava field	Roobol and Camp
DGMR-TR-92-3	Earth Fissures at Al Yatimah	Roobol, Al-Rehaili, and Bankhar

1993 REPORTS

Report No.	Brief Title	Authors
USGS TR-93-1	Annual Report for 1992	USGS
USGS OF-93-1	Tabulation of previously published U-Pb, Rb-Sr and Sm-Nd numerical age data for the Precambrian of NE Africa & Arabia	Johnson, Carten and Jastaniah
USGS OF-93-5	Magnetic anomalies and basement structure in C. Arabia	Johnson and Stewart
USGS TR 93-3	The Bi'r Hamadan mineral belt	Bosch
USGS TR-92-9	Geochem. exploration - Hamdah-Jabal Riah gold district	El Komi and Carten
USGS TR 92-10	Gold prospects of the Jabal Riah mineral belt	Carten
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APPENDIX 2. Summary of reports published by the USGS Saudi Arabian Mission--
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