REPORT
ON
THE MINERAL EXPLORATION
IN
THE ZHAMAN-AIBAT AND SAMARSKY AREA
REPUBLIC OF KAZAKHSTAN

(PHASE I)

MARCH 1995

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request from the Government of the Republic of Kazakhstan, the Japanese Government decided to conduct a Mineral Exploration Project in the Zhaman-Aibat and Samarsky Areas and entrusted the survey to the Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to Kazakhstan a survey team headed by Mr.Akeo Onishi from 29 November, 1994 to 18 February, 1995.

The team exchanged views with the officials of the Government of the Republic of Kazakhstan and conducted a field survey in the Zhaman-Aibat and Samarsky Areas. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relation between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Kazakhstan for their close cooperation extended to the team.

March 1995

Kimio Fujita
President
Japan International Cooperation Agency

Takashi Ishikawa
President
Metal Mining Agency of Japan

SUMMARY

The three year's mineral exploration program in the Zhaman-Aibat area and in the Samarsky area, Central Kazakhstan, has been launched with the aim of exploring and evaluating mineral resources in these areas.

The primary aim of the program in this year was to study and evaluate the previous exploration data to confirm the geology of the ore deposit, to verify the occurrence of the minerals and to re-evaluate the mineral deposit previously surveyed by the organization of the Kazakhstan Government.

In conjunction with these studies and evaluations, a secondary aim was to provide the staff of the Kazakhstan Government and of Kazakhstan private companies with the technology required to proceed with their daily works in these areas.

The work on the data analysis of the Zhaman-Aibat area was done at the Zhezkazgangeologiya and of the Samarsky area was done at the Karagandageologiya.

The study and evaluation include the following:

① review of the survey area,

② selection of the data required for ore reserve estimation,

③ compilation of survey data,

④ listing of previous survey data.

Based on the result of the study and evaluation of the previous exploration data, the data input of drillings and chemical assays was done and various maps and figures which are needed to estimate the ore reserve of the Zhaman-Aibat copper deposit and the Samarsky copper-molybdenum deposit were prepared. In the Zhaman-Aibat deposit, an ore reserve estimation on "Block-A", a part of the Eastern Orebody was carried out. In the Samarsky deposit, an ore reserve estimation on the porphyry copper-molybdenum deposit was carried out. The results of the calculation by the Japanese survey team were correlated to those of the Kazakhstan team and showed a good match between the two calculations.

The results of the survey and the evaluation are summarized as follows:

(1) In the Zhaman-Aibat copper deposit, a huge number of drillings (200mx200m grid pattern) has confirmed the areal extent of the copper deposit. The exploration stage is now proceeding to the advanced (more detailed) stage. However, there still remain some important item that should be studied before the new exploration program starts. These studies include items, such as geostatistical investigation of the present drilling spacing, future mining methods in the deeper levels, discrepancies in chemical assay results between the Japanese survey team and the Kazakhstan team.

(2) In the Samarsky copper-molybdenum deposit, it is confirmed that the high grade copper mineralized zone of the surveyed deposit is located deep beneath the surface. Considering the reality of the actual mining operation, some difficulties of the deeper mining are expected. Thus, future exploration should focus on surveys for finding new copper-molybdenum mineralization at shallower depth. Potential areas still remain in the surrounding area, and it is expected that new ore deposit will be found.

Based on the results, it is recommended that the following work be carried out in the 1995 campaign:

(1) Remote sensing data analysis in the Samarsky area.
(2) Survey and evaluation of the previous exploration data taken in the areas of Zhaman-Aibat and Samarsky.
(3) Electric survey (charged potential survey) in the Samarsky copper-molybdenum deposit and in the surrounding areas, and seismic exploration (reflection wave method) in the Samarsky gold-bearing polymetallic deposit area.
(4) Drillings in the Samarsky copper-molybdenum, and gold bearing polymetallic deposits and in the Zhaman-Aibat copper deposit.
(5) Geological ore reserve estimation on the Samarsky copper-molybdenum deposit, gold bearing polymetallic deposit and on the Eastern and the Central Ore bodies in the Zhaman-Aibat deposit.
(6) Pre-studies are; a) Geostatistical study on the appropriate drilling spacing in the Zhaman-Aibat copper deposit. b) Checking the chemical assay methods and results, c) Innovation of future mining methods.

Резюме

Резюме

Изучение по сотрудничеству в разработке полезных ископаемых месторождений Жаман-Айбат и Самарское в Республике Казахстан является трехгодичным проектом, который начался в 1994 году и ставит целью разведку минеральных ресурсов и оценку ресурсов на данных месторождениях. Цель изучения этого года состоит в исследовании и анализе материалов, полученных в результате поисковых работ, уяснении геологического состояния и рудоносности, переоценке рудных месторождений. Кроме того, в течение срока изучения ставится целью провести обмен мнениями с представителями Казахской стороны и передать им необходимые технологии. Анализ в части изучения существующих материалов проведен в "Жезказгангеологии" в отношении месторождения Жаман-Айбат и в "Карагандагеология" в отношении месторождения Самарское. В рамках этих исследований и анализа выполнено: 1) обзор материалов исследований; 2) подбор материалов, необходимых для оценки рудного месторождения; 3) компилирование данных; 4) составление перечня материалов исследований. На основе результатов этих исследований и анализа выполнено бурение, ввод данных анализа, подготовка лабораторных данных, необходимых для ориентировочного подсчета рудных запасов. Был выполнен ориентировочный подсчет геологических запасов, проведено сравнение с аналогичными данными партнера и их рассмотрение как для Блока-А, который является частью восточного рудного тела на месторождении Жаман-Айбат, так и для медно-молибденового месторождения Самарское. Ниже представлены результаты указанных исследований и анализа.

1) Границы размещения рудоносного месторождения выясняются с помощью множественного бурения (сеткой 200 м x 200 м). Разведка переходит на новый этап, однако еще нужно рассмотреть вопросы относительно приемлемости применяемой ныне сетки бурения, метода геолого-разведочных работ в будущем, показателей химического анализа и т.д.

2) Поскольку разведанная часть рудоносного месторождения медного-молибденового месторождения в районе Самарское имеет выраженное глубинное залегание, то представляется, что дальнейшие геолого-разведочные работы и разработка будут сопровождаться трудностями. Поэтому в дальнейшем геолого-

разведочные работы нужно вести с упором на медно-молибденовое оруденение, имеющее более мелкое залегание. Вокруг разведанного месторождения общая площадь геолого-разведочных работ имеется в достаточном количестве, поэтому высока вероятность нахождения нового месторождения.

Основываясь на вышесказанном, в качестве дальнейших исследований предлагается следующее:

(1) Провести дистанционное зондирование, взяв за объект район Самарское

(2) Провести изучение и анализ существующих материалов в отношении месторождений Самарское и Жаман-Айбат

(3) Провести электроразведку на медно-молибденовом месторождении Самарское и периферийной области (токовая потенциометрия), а также сейсмическую разведку на золото-полиметаллическом месторождении (по методу преломленных волн)

(4) Бурение на медно-молибденовом и золото-полиметаллическом месторождении района Самарское, а также на месторождении Жаман-Айбат

(5) Ориентировочный подсчет геологических запасов на медно-молибденовом, золото-полиметаллическом месторождении района Самарское, восточного и центрального рудных тел месторождения Жаман-Айбат.

(6) В качестве предварительного рассмотрения указанных выше подсчетов рудных запасов, провести рассмотрение вопросов по оптимальной сетке бурения разведочных скважин на основе методов геологической статистики, показателей химического анализа, а также метода добычи руды.

1. Комплексное рассмотрение результатов изучения

1-1 Анализ изображений со спутника "Ландсарт" (искусственного спутника для съемки поверхности земли)

Выполнена разнородная дешифровка спутниковых изображений района Жаман-Айбат на основе методов фотогеологии, а также спектральный анализ

1-1-1 Геологический анализ космических снимков

В результате фотогеологического анализа с использованием снимков со спутника (RGB;541) района месторождения Жаман-Айбат мы смогли получить много информации о топографии, геологической стратиграфии, геологической структуре. В топографической расшифровке исследуемый район подразделялся на 3 части: пустыня, низменность и холмы. Результаты их топографической дешифровки точно отражают состояние местности, и было подтверждено, что они чрезвычайно полезны для изучения на месте. В рамках геологической дешифровки с помощью цветовой текстуры по направлению снизу вверх было выделено 10 геологических подразделений и частей подразделений. Однако обозначенного на существующих геологических картах подразделения, который соответствует каменноугольной системе, с помощью фотогеологического анализа выделено не было. Следовательно, в отношении результатов анализа необходимо проверять геологию, соответствующую каждому геологическому подразделению геологической съемкой.

При дешифровке геологической структуры в центральной части данного района на антиклинальной оси северо-восток-восток - юго-запад-запад была выделена антиклинальная структура, расположенная в направлении юго-запад-запад. Был выделен разрыв меридионального простирания, а также линеаменты с простиранием северо-восток - юго-запад и кольцевой структуры. Их геологическая структура аналогична существующим геологическим картам, однако в отношении подробностей требуется провести маршрутную геологическую съемку.

1-1-2 Зона изменения

В области с центром из поднятия Жаман-Айбат из изображения компьютерной обработки удалось выделись 3 характерных оттенка (RGB; 5/7,5/4,3/1). Эти оттенки включают синюю часть, распространяющуюся на западный район поднятия, краснофиолетовую часть, в виде конфигурации, окружающей полукругом данное поднятие, и простирающуюся между ними желто-зеленую часть. Согласно геологической дешифровке синяя часть соответствует пласту красных песчаников каменноугольного периода. Существует возможность выделить гидроокисленной железной руды, содержащейся в пласте красных песчаников. Кроме того, поскольку пласт красных песчаников является рудоносным горизонтом данной зоны, то этот синий цвет даст ценный материал для того, что проследить аналогичные горизонты осадочной породы в периферийной зоне. Согласно геологической дешифровке большинство случаев красно-фиолетовой части спектра включается в пласт четвертичного периода. Если исходить из местных материалов, то наиболее красный участок красно-фиолетовой части спектра соответствует расположению озер, которые расширяются в летнее время. Поскольку во время изучения на месте в этот раз не удалось в достаточной степени провести изучение поверхности земли, то трудно судить о наличии глинистых минералов красной части спектра. Согласно геологической дешифровке желто-зеленая часть соответствует пласту продуктов выветривания, имеющего большие рамки распространения в данной местности, но не имеет отношения к зоне изменения.

Исходя из вышесказанного, изменение в зоне изучения имеют характеризуются наличием железного колчедана, гидроокисленной железной руды. Размещение этой зоны изменения удалось выделить в синем цвете с помощью обработки компьютерного изображения. Даже во время нынешнего изучения частично удалось подтвердить, что синий оттенок является пластом красных песчаников рудоносного горизонта.

Также кроме того, из частичной дешифровки снимков (RGB;541) в оттенках желтого и оранжевого цвета отмечается возможность наличия изменения характерных признаков пород. Однако их геологические элементы являются являются гораздо более высокими пластами по сравнению с сообщаемым рудоносным горизонтом. В следующем году нужно провести геологическую съемку по поводу спектрального анализа пород их геологических элементов и участков оттенков красного и фиолетового цветов изображения компьютерной обработки.

1-2 Геология и месторождение

1-2-1 Район Жаман-Айбат

(1) Месторождение залегает в восточной оконечности впадины Жезказган-Сарысу и образуется в среде отложений среднего-позднего Каменноугольного периода, а также аллювиально-дельтовых отложений раннего пермского периода, и является напластованным месторождением медистого песчаника, коренящегося в сером песчанике в так называемом пласте красного песчаника.

(2) До настоящего времени на месторождении Жаман-Айбат было пробурено около 800 скважин (по сетке 200 м х 200 м), и было подтверждено наличие трех рудных тел: восточного центрального и северного. Эти рудные тела залегают в пределах 12,5 км с запада на восток и 5 км с севера на юг. Глубина рудообразования в восточной части составляет 400-500 м от поверхности, по направлению к западу глубина увеличивается и на западной оконечности центрального рудного тела составляет 700-750 м.

(3) Среди минералов, составляющих месторождение, в наибольшем количестве имеются халькозин и борнит, сопровождающиеся малым количеством медного колчедана. Также подтверждено наличие в незначительном количестве свинцового блеска, цинковой обманки, теннантита, дигенита и природного серебра. По комбинациям этих рудных минералов классифицированы 4 типа руды: медная руда (Cu), полиметаллическая руда (Pb+Zn+Cu), свинцово-цинковая руда (Pb+Zn), серебряная руда (Ag+Cu).

(4) Во время более ранних исследований на месторождении Жаман-Айбат было подтверждено наличие 10 рудоносных горизонтов в пласте песчаника каменноугольного периода. Предполагается, что 2-3 горизонта из этого числа могут стать предметом для подсчета запасов. В особенности толщина рудного пласта и содержание меди в горизонте 4-I превосходит другие, и он составляет основную часть месторождения Жаман-Айбат.

1-2-2 Район Самарское

(1) На данном месторождение признается наличие месторождений двух типов: медно-молибденовое месторождение порфирного типа и золото-полиметаллическое месторождение. В центре находится зона оруденения Cu-Mo, а вокруг ее (по краю) залегает участок золота-полиметаллов, что говорит о наличии зональности.

(2) Медно-молибденовое месторождение порфирного типа

(а) Медно-молибденовое месторождение порфирного типа включает в себя то, что заменило основную породу вулканической трубки, образованной в результате деятельности андезита-базальтовой лавы, проникших через их обломные и осадочные породы кварцевый диорит почти того же времени и кварцедиоритовый порфир, интрузия которого произошла позже, а также интрузивная порода и то, что располагается по ее периферии в основном в виде вкраплений.

(б) Среди рудных минералов первичным минералом является медный колчедан, который сопровождается чрезвычайно незначительном количеством халькозина и борнита. Из вторичных минералов обнаружены малахит, а также в совсем незначительном количестве хризоколла и азурит.

(в) Окисление обнаружено до глубины 30-50 м от поверхности, а при дальнейшем продвижении в глубину начинается зона первичных сульфидных минералов. Однако зоны вторичного обогащения не обнаружено. Участки с высоким содержанием меди от 1% и выше в зоне первичных сульфидных минералов размещается только внутри вулканической трубки, о которой говорилось ранее, а породу между брекчиями заменяет медный колчедан-кварц. Следовательно, форма рудного тела отражает форму вулканической трубки, а начиная с 300 м от поверхности в дальнейшем движении вглубь имеет более расширенную форму. Частью пробуренных скважин было подтверждено, что это орудение непрерывно продолжается до глубины 750 м.

(г) Что касается гидротермального изменения, то в середине размещаются калиевая зона изменения и кварцево-серицитовая зона, но их внешнему краю - зона пропитилизации, а затем за пределами этой зоны - зон аргиллизации. Считается, что в особенности калиевая зона изменения и кварцево-серицитовая зона имеются на глубине свыше 500-600 м, а у поверхности земли широко располагаются зоны пропитилизации и аргиллизации.

(3) Месторождение золота-полиметаллов

(а) Золото-полиметаллическое месторождение залегает по внешнему краю зоны указанного выше медно-молибденового месторождения порфирного типа, а именно размещается в зоне разломов, возникших на верхних пластах сложных разрывов, простирающихся северо-западной- западной части района изучения почти что в меридиональном направлении. До настоящего времени разведаны основная жила и 3 ветвящиеся жилы.

(б) В результате более раннего бурения в рамках геолого-разведочных работ предполагается, что простирание вышеуказанных сульфидов золота - полиметаллов кварцевых/нитевидных жил имеет почти точную меридиональную направленность, склон 35-50° W, средняя ширина жилы 5,6 м, среднее содержание золота 3,82 г/т, серебра и меди 20 г/т (расчет партнеров), в направлении простирания приблизительно на 800 м, в направлении склона на 1000 м, вглубь на 350 м обнаружено оруденение.

(в) Среди минералов, формирующих рудную жилу, в основном имеются кварц, сопровождаемый свинцовым блеском, цинковой обманкой, медным колчеданом. Золото обнаруживается в виде природного золота внутри кварцевой жилы, а также в свинцовом блеске, медном колчедане и железном колчедане.

(г) Среди гидротермальных изменений отмечаются серицитизация, карбонатизация, аргиллизация, окварцевание.

2-3 Рассмотрение результатов

1-3-1 Района Жаман-Айбат

(1) В этом году на основе метода Полгона был выполнен подсчет запасов "Блока-А", который в восточном рудном теле является частью с высоким содержанием рудного горизонта 4-I, для чего использовались 217 разведочных скважин, лабораторные данные в количестве 1996. В результате этого геологические запасы (не промышленные запасы) составили 84 млн. тонн, содержание меди 1,8% (однако содержание низшего сорта руды данного месторождения, принятого при подсчете запасов - 0,4%), средняя толщина рудного тела 5,45 м, что практически соответствует результатам предположений.

(2) Ориентировочный подсчет запасов, выполненный во время изучения этого года, является в любом случае подсчетом "геологических запасов". Предполагается, что цифра запасов станет меньше, и содержание металла ниже в случае проведения в дальнейшем ориентировочного подсчета промышленных запасов с четом условий разработки.

(3) До настоящего времени бурение проводилось виде сетки 200 х 200 м, тем не менее с точки зрения последующих оценок месторождения существует необходимость подтверждения

приемлемости сетки бурения в 200 м х 200 м с использованием методов геологической статистики.

(4) Как показывают результаты выполненного контрольного анализа образцов анализа партнера (50 шт.), выяснено, что значение анализа, выполненного партнером по меди, составляет в целом около 7,6%. Разрыв между этими двумя значениями анализа может быть исправлен с помощью корректирующей формулы, однако поскольку разница в значениях слишком велика, нужно впоследствии еще раз провести контрольный анализ и, рассмотрев результаты, исправить значения на соответствующие.

(5) В настоящее время ряд работ, начиная от заполнения журналов результатов анализа до составления итоговых журналов по результатам подсчета запасов выполняется с привлечением большого числа персонала и специалистов, все путем ручной работы. Недавно было составлено несколько томов журналов (ведомостей геологических данных). В этом процессе неизбежно возникает неразбериха по причине ошибок в записях, повторении данных, пропуске данных, отсутствие единства формата, поэтому доверие к самим таким журналам падает. Следовательно, для уменьшения ошибок и неразберихи необходимо внедрить унифицированную систему управления данными на базе компьютеров.

1-3-2 Район Самарское

(1) Выполнен ориентировочный подсчет запасов месторождения для чего использовались 12 скважин, которые подтвердили наличие месторождения в центральной зоне Самарского, из числа 46 скважин пробного бурения, выполненных до настоящего момента и общей длины проходки 27976 м, а также 937 лабораторных данных. В результате получено, что геологические запасы (не промышленные запасы) составляют 114 млн. тонн, предполагаемое среднее содержание меди 1,2% (однако содержание низшего сорта руды данного месторождения, принятого при подсчете запасов - 0,5%), при этом предполагаемое среднее содержание золота - 0,48 г/т, а этот же показатель для молибдена - 0,01%.

(2) Подсчет запасов месторождения в этом году выполнялся по методу поперечных разрезов, который применяется длительное время, однако абсолютное число пробуренных скважин, особенное число скважин, подтвердивших наличие месторождения, чрезвычайно мало, поэтому есть проблемы с точностью разреза

месторождения, а именно с самой площадью поперечного разреза месторождения. Поэтому предполагается, что точность подсчета запасов находится на достаточно низком уровне.

(3) Разведанные месторождения залегают на глубине 300 и ниже, поэтому ожидается, что разработка месторождений в будущем встретит трудности. В настоящее время в восточной части разведанного месторождения проходят геолого-разведочные работы оруденения Cu-Mo порфирного типа, сопровождающего вулканическую трубку. Нужно и дальше продолжать геолого-разведочные работы по размещению и зоне интрузий и вулканических трубок, залегающих в более мелких местах. Конкретно мы думаем, что наиболее подходящими для геолого-разведочных работ являются следующие места: восточная оконечность кварцевого диорита северо-восточной и восточной части разведанного месторождения, вулканическая трубка, простирающаяся приблизительно на 1 км на юго-восток от разведанного месторождения и область вокруг нее, участок между разведанным месторождением и разрывом Тулкулинским.

2. Выводы и предложения

В качестве результатов изучения нынешнего года можно привести следующие пункты.

(1) Месторождение Жаман-Айбат, медно-молибденовое месторождение и золото-полиметаллическое месторождение района Самарское имеют весьма важное значение для Республики Казахстана в качестве источника этих металлов. В дальнейшем необходимо не только проводить геолого-разведочные работы новых месторождений, но также и проводить оценку выявленных месторождений доразведкой.

(2) Медное месторождение Жаман-Айбат напластованным месторождением в виде медистого песчаника чрезвычайно похоже на разрабатываемое ныне Жезказганское месторождение, что делает возможным применение технологии разработки и обогащения. Как можно скорее нужно рассмотреть вопросы о приемлемости существующей сетки разведочного бурения, которая стала известна в этот раз, методе геолого-разведочных работ в будущем, значений анализа, а также провести оценку месторождений.

(3) Разведанная часть медно-молибденового месторождения порфирного типа района Самарское имеет достаточно глубокое

залегание, поэтому если говорить о добыче в будущем, то нужно искать медно-молибденовые оруденения, которые залегают на небольшой глубине в периферийной области. Кроме того, нужно проводить геолого-разведочные работы месторождения золота-полиметаллов в отношении неразведанных районов.

(4) В настоящее время во время геолого-разведочных работ на месторождении Жаман-Айбат различные работы от составления журналов до составления журналов результатов подсчета запасов выполнялись путем ручных операций. Было составлено несколько геологических ведомостей. При этом возникло много ошибок, что что снизило надежности данных. Для решения этих вопросов нужно ввести унифицированную систему контроля данных на базе компьютеров.

(5) Поскольку границы залегания месторождения Жаман-Айбат были определены ранее, то геологоразведка переходит на новый этап. Поэтому в дальнейшем проводить геофизическую разведку на данном месторождении нет необходимости. С другой стороны, на медно-молибденовом и золото-полиметаллическом месторождениях в районе Самарское нужно выполнить геофизическую разведку и бурение не только по периферии выявленного месторождения, но также и на новых участках для выявления новых месторождений.

В качестве геолого-разведочных работ на 1995 год предлагается следующее:

(1) Дистанционное зондирование

Анализ данных дистанционного зондирования района Самарское и маршрутная геологическая съемка

(2) Обзор, оценка и анализ существующих данных

В отношении указанных ниже данных оценку и анализ нужно провести в особенности.

(а) Данные по восточному рудному телу и центральному рудному телу месторождения Жаман-Айбат

(б) Данные разведки медно-молибденового и золото-полиметаллического месторождений в районе Самарское и их периферийной области

(3) Геофизическая разведка

(а) Электроразведка (токовая потенциометрия) с целью выяснения пространственного залегания медно-молибденового оруденения порфирного типа , ограниченного интрузией.

(б) Сейсморазведка (по методу преломленных волн) для понимания геологического строения, ограничивающего золото-полиметаллическое месторождение

(4) Бурение

(а) На медно-молибденовом месторождении района Самарское: разведка расположения интрузий, имеющих неглубокое залегание, и разведка вулканических трубок; бурение для подтверждения оруденения в удлинении южной части и глубинной части на золото-полиметаллическом месторождении.

(б) Бурение для получения базовых данных на месторождении Жаман-Айбат

(5) Подсчет запасов

Подготовка для создания базы данных для оценки месторождения в будущем

(а) ввод данных

Район Самарское:	данные по месторождению Cu-Mo порфирного типа и месторождению золота-полиметаллов, данные около 80 разведочных скважин
Район Жаман-Айбат	данные по центральному и восточному рудным телам, данные около 300 разведочных скважин

(б) Подсчет запасов

Район Самарское	месторождение Cu-Mo порфирного типа, месторождение золота-полиметаллических руд
Район Жаман-Айбат	восточное и центральное рудные тела

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PART I
GENERAL

PART I GENERAL

1 Introduction

1-1 Objective of the project

The main objective of the project is to explore and to assess the mineral potential of the Zhaman-Aibat area and the Samarsky area in the Republic of Kazakhstan. The objectives of phase 1 (1994FY) are to unravel the geology and mineralization in the survey aras, to select promising areas, and also to establish a detailed plan for phase 2 (1995FY).

1-2 Outline of phase I survey

The Survey will be carried out within a period of three years commencing from 1994. The regions to be surveyed cover an area of approximately 1,800 square kilometers for the Zhaman-Aibat area and an area of approximately 250 square kilometers for the Samarsky area shown on the location map (Figure 1). The Survey will be carried out by means of geological, geochemical and geophysical surveys and drilling. Processing and compilation of the results of the survey will be made in Japan and/or Kazakhstan.

The method of the survey on phase 1 in 1994FY are satellite image analysis, data compilation and geological survey. The scope of the work during 1994FY is as follows:

1) Satellite image analysis

Objective: To reveal lineaments and geological structure and to extract alteration zones.

Survey area: The survey area is shown in Figure I-2-1-1

Satellite data: Landsat TM5

Place of analysis: Japan (data processing)

2) Data compilation

Objective : To review and study previous works in order to assess known mineral showings and preliminarily evaluate the potential of the Zhaman-Aibat and Samarsky deposits.

Previous data: Previous survey data obtained are shown in Table 1.

Survey area: The survey area is shown in Figure I-2-1-1 and Figure I-2-1-2

Place of compilation:

Ministry for Geology and Conservation of Mineral Resources(hereinafter referred to as MFG) office in Almaty, Zhezkazgan and/or Karaganda

3) Geological survey

Objectives: To check the results of the satellite image analysis and data

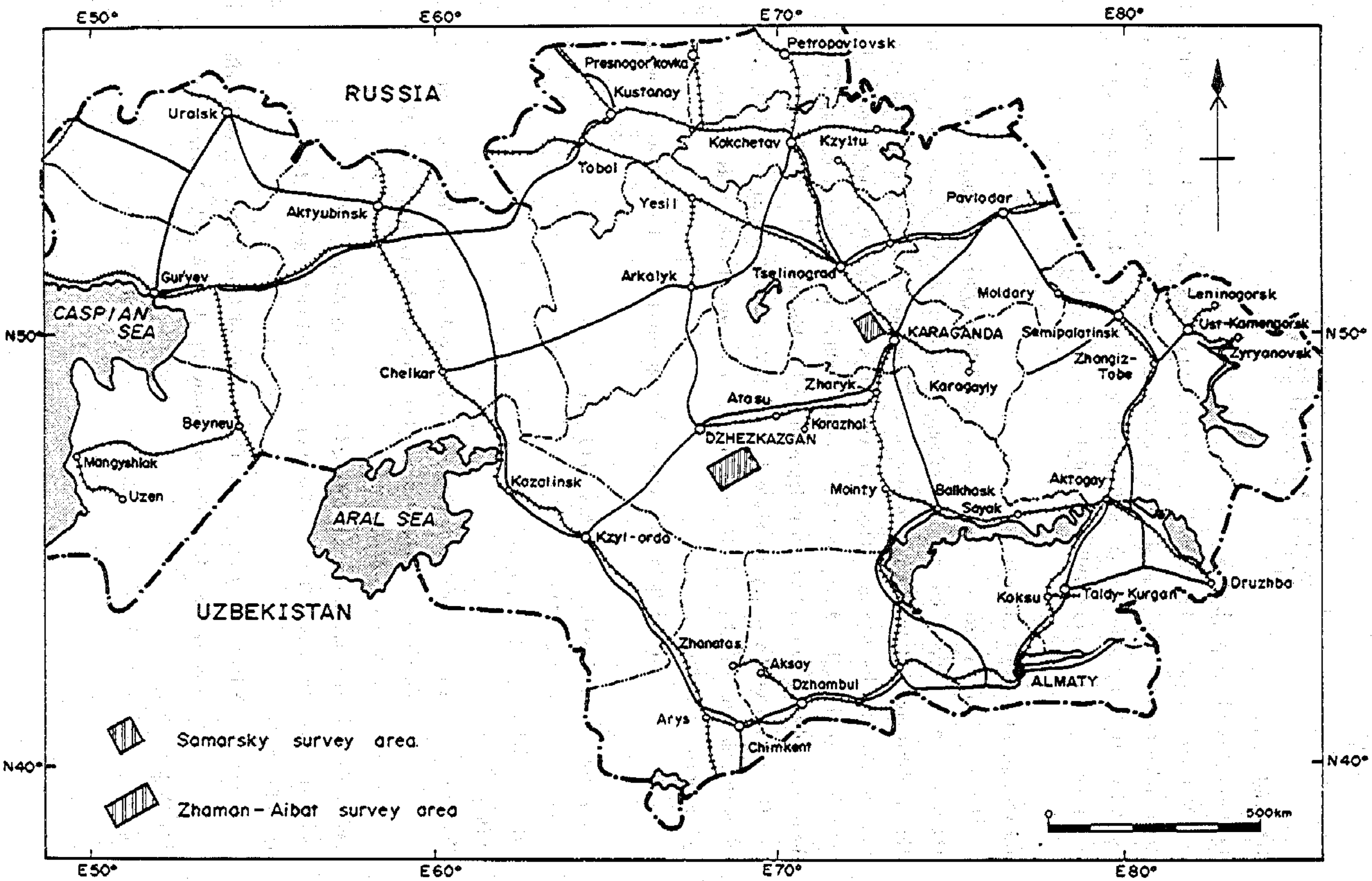

Figure 1 Location Map of Project Areas

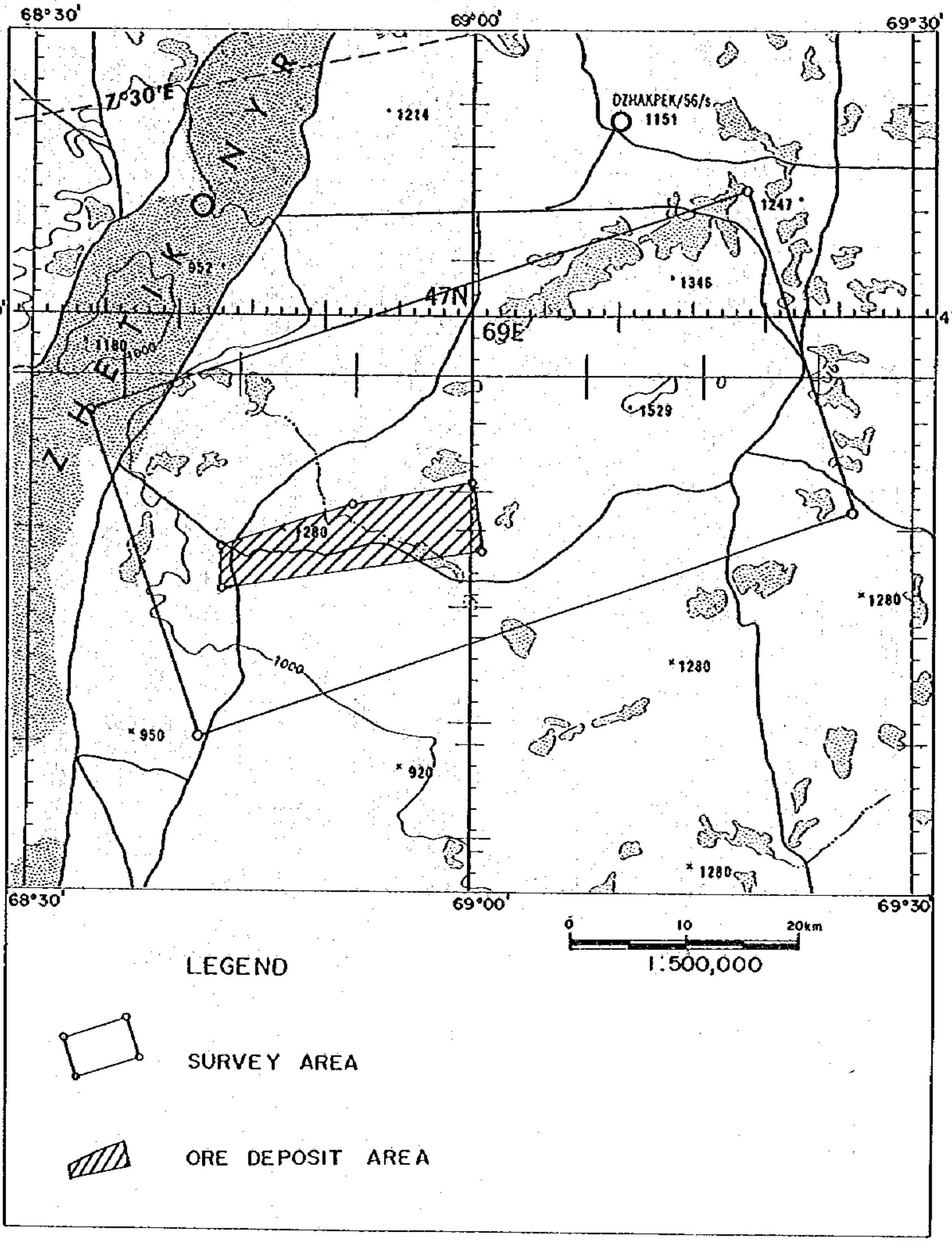

Figure I-2-1-1 Location Map of the Zhaman-Aibat Area

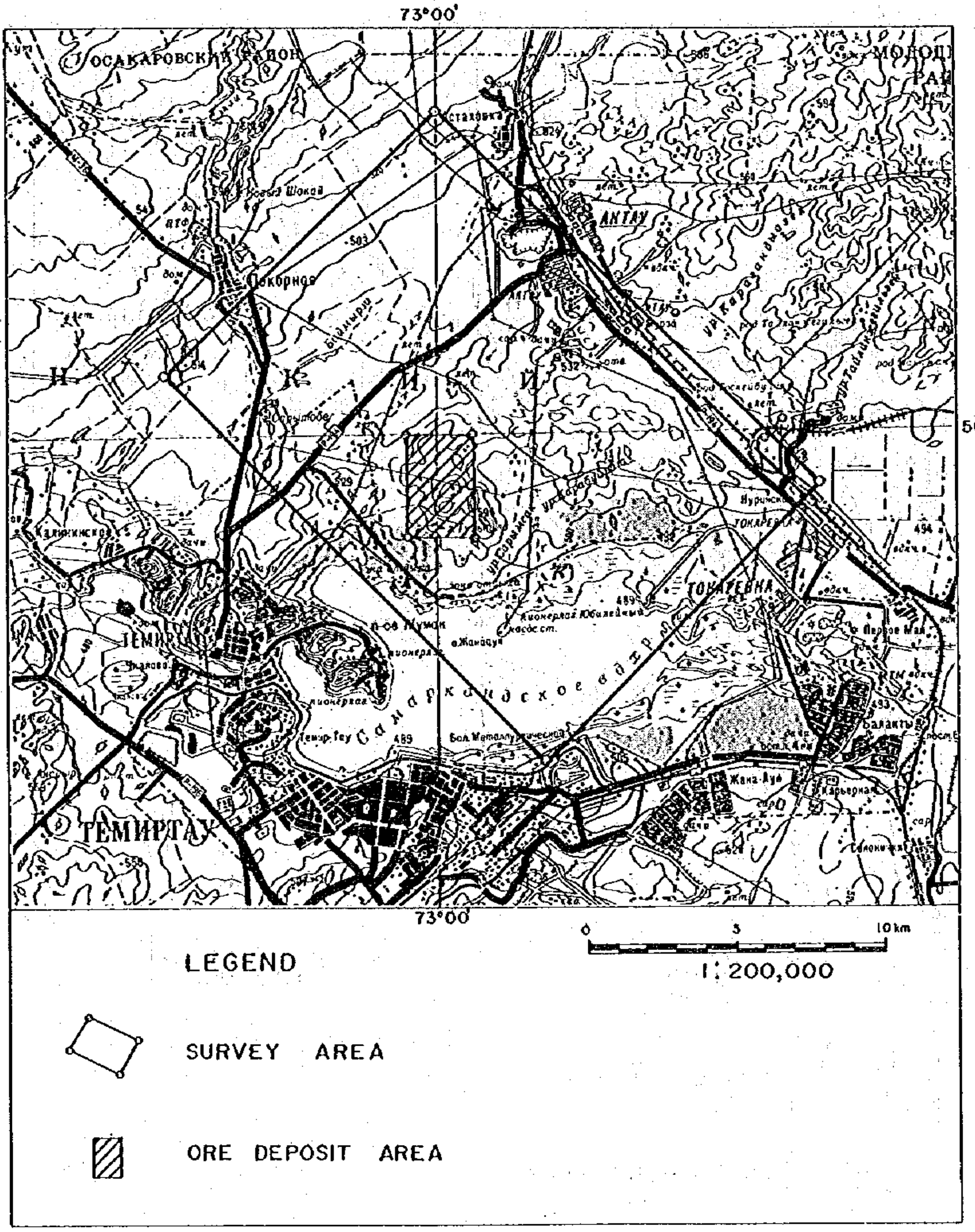

Figure I-2-1-2 Location Map of the Samarsky Area

Table 1　List of Previous Survey Data

Zhaman–Aibat Area

Title	Scale
Geological Map	1:500,000
	1:100,000
	1: 50,000
	1: 25,000
Geological Cross–Section	1: 5,000
	1: 2,000
Relief Map	1:200,000
	1: 50,000
	1: 10,000
Geomorphology Map	1:100,000
Drill Location Map	1: 25,000
Ore Block Map of Deposit 4–I	1: 10,000
	1: 5,000
Magnetic Anomaly Map	1:100,000
Gravity Anomaly Map	1:100,000
Electrical Exploration Map	1:100,000
Geochemical Map	1:100,000
Tectonic Map	1:100,000

Samarsky Area

Title	Scale
Geoological Map	1:500,000
	1: 50,000
	1: 10,000
	1: 2,000
Geological Cross–Section	1: 10,000
	1: 2,000
Relief Map	1:200,000
	1: 50,000
	1: 25,000
	1: 10,000
Level Sliced Map	1: 2,000
Drill Location Map	1: 10,000
	1: 2,000
Ore Block Map	1: 2,000
Core Logging	1: 200
Magnetic Anomaly Map	1: 50,000
	1: 25,000
	1: 10,000
	1: 2,000
Bouger Anomaly Map	1: 50,000
	1: 25,000
Electrical Exploration Map	1: 10,000
Geochemical Map	1: 25,000
	1: 10,000
Tectonic Map	1:100,000

compilation

Survey area: The survey area is shown in Figures I-2-1-1 and Figure I-2-1-2

4) Laboratory works in Japan

Observation of thin sections:	10
Observation of polished sections:	10
Whole rock analysis:	10
-SiO_2,TiO_2,Al_2O_3,Fe_2O_3,FeO,CaO,MnO,Nc_2O,MgO,K_2O,P_2O_5,LOI	
Geochemical analysis:	20
-Au,Ag,Cu,Pb,Zn	
Assay of mineralized samples:	30
-Au,Ag,Cu,Pb,Zn	

5) Data base constructed for ore reserve estimation

Entered data are as follows:

	Zhaman-Aibat (since 1981)	Samarsky (since 1989)
No. of drill:	808+126(technical drills)	46
Total drill length:	619,466.3m	27,976m
(Input data)		
Drills:	305	30
Data sets:	2,862	2,197
Elements:	Cu,Pb,Zn,Ag	Cu,Mo,Au,Ag
(Ore reserve estimation)		
Used drills:	217	12
Used data sets:	1,996	937
Elements:	Cu,Pb,Zn,Ag	Cu,Mo,Au,Ag

1-3 Survey duration

1) The works in the Republic of Kazakhstan

For the first year's campaign, the field work commenced on December 3rd, 1994 and was completed on February 15th, 1995.

Zhezkazgan (Zhaman-Aibat area) :

December 11th, 1994 to January 10th, 1995

January 30th, 1995 to February 1st, 1995

Karaganda (Samarsky area) :

December 8th, 1994 to December 9th, 1995

January 12th, 1995 to January 31st, 1995

Almaty (Data collection, Data analysis) :

December 4th, 1994 to December 9th, 1994
February 2nd, 1995 to February 14th, 1995

2) The works in Japan:

February 18th, 1995 to February 28th, 1995

1-4 Project staff and field survey team

Project staff

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Mr.Masamo Kando (Mining Division, MITI*[1])	Mr. Bitimbaev Zh.M. (Deputy Minister, MFG*[2])
Mr.Fumihiro Ono (Mining Division, MITI)	Mr. Tjugai M.O. (Head of Mineral Resources Department, MFG)
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*[1] Ministry of International Trade and Industry

*[2] Ministry for Geology and Conservation of Mineral Resources of the Republic of Kazakhstan

*[3] Japan International Cooperation Agency

*[4] Metal Mining Agency of Japan

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Mr. Gusev N.M.
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Mr. Kasimovski P.
(Chief Engineer)
Mr. Suleimenov K. Mr. Uzhuva V.
(Chief Geologist) (Chief Geologist of The Zhaman-Aibat Project)
Mr. Kazimir V.
(Chief Geophysicist)
Mr. Ospanov K
(Manager of Production)

2 Geography of the survey area

2-1 Location and access

The Zhaman-Aibat copper deposit area is located in the Zhana-Arkin district of the Zhezkazgan region 180 km to the south-east of Zhezkazgan. Geographic coordinates are 46° 50′ north and 68° 54′ east. The Zhaman-Aibat copper deposit area can be accessible by car from Zhezkazgan through the Zhezkazgan-Kzyl-Orda highway and mainly not paved roads. The nearest railway station is the Zhezkazgan station 180km to the north-west of the deposit.

The Samarsky copper deposit area is located in the Telmansky district of the Karaganda region 35 km to the north of Karaganda and 10km to the north of Temirtau. Geographic coordinates are 50° 09′ north and 73° 00′ east. Access to the Samarsky copper deposit from Karaganda is through the highway Karaganda-Temirtau-Polomoye-Tselinograd route (No.36) and not paved roads.

The nearest railway stations are at Akutau, 10km to the north-east of the area, and at Tokarevka, 15 km to the east of the area.

2-2 Topography

Topography of both survey areas belongs to the "stage of old age" or "peneplain" topographic classification and is characterized by low hills. There are few permanent water courses and the only depressions in the area are between adjacent hills, which channel melted snow, and rarely rain water, during the spring.

The altitude of the Zhaman-Aibat copper deposit is approximately 320-380m above sea level. The highest point in the area of the deposit is 376.7m in altitude and the lowest point is 318.0m. The altitude of the Samarsky copper deposit is approximately 490-590m above sea level. The highest point in the area of the deposit is 594.2m in altitude and the lowest point is 489.3m.

2-3 Climate and vegetation

Climate of both survey areas is sharp continental and is classified as a zone of dry feather-grass steppe. Those areas are arid in all seasons with very small amounts of rain in summer and several tens of centimeters of snow in winter.

In the Zhaman-Aibat area the average annual temperature is +5.5°C with the average monthly summer temperature up to +33°C. In winter the temperatures fall to -33°C. The average precipitation in the area is 140-150mm per annum (Table I-2-3-1).

In the Samarsky area the average annual temperature is +3.1°C with an average monthly summertime temperature up to +23°C. In winter temperatures are as low as -18°C. The average annual precipitation does not exceed 250 mm, but 1992 and 1993 were extraordinarily wet years (Table I-2-3-2).

The vegetation in these areas is very thin. With a sharp continental climate, the surface of the ground is rarely covered by xerophytic vegetation in the summer season. The major vegetation in both survey areas is feathergrass, sagebrush and other groups of grasses. Therefore, it is very suitable for exploration by remote-sensing methods.

Table I-2-3-1 Climatological Data of the Zhezkazgan and the Zhaman-Aibat Areas

(Zhezkazgan City)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave. /Total
Average Temperature (℃)	-16.0	-14.6	7.2	6.2	15.5	21.6	24.0	21.4	14.4	4.8	-5.1	-12.8	5.5
Precipitation (mm)	13	12	14	14	11	17	16	11	8	12	10	12	150

Maximum Temperature 43.0 ℃
Minimum Temperature -50.0 ℃

(Zhaman-Aibat Exploration Camp)

Monthly average temperature in June - July 33.0 ℃

Average annual precipation : 150 mm
Precipation occur during summer months (June-August)
Total snow covered days are 120 - 150 days

Table I-2-3-2 Climatological Data of the Karaganda and the Samarsky Areas

Year	Item \ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave. /Total
1991	Ave. Monthly Temp. (°C)	-12.5	-15.4	-9.0	5.9	14.2	21.6	21.3	16.5	14.1	8.4	-1.7	-10.4	4.4
	Precipitation (mm)	44.	4.	14.	7.	42.	3.	26.	19.	18.	14.	22.	35.	248.
1992	Ave. Monthly Temp. (°C)	-8.7	-11.4	-9.2	5.1	11.9	15.7	19.9	16.3	7.7	3.8	-3.2	-9.7	3.2
	Precipitation (mm)	30.	10.	11.	38.	43.	39.	16.	64.	35.	19.	3.	36.	344.
1993	Ave. Monthly Temp. (°C)	-11.4	-13.5	-7.0	3.2	10.8	18.1	18.9	18.1	8.3	4.0	-13.7	-13.8	1.8
	Precipitation (mm)	29.	33.	48.	46.	32.	47.	77.	19.	10.	9.	16.	10.	376.
1991-1993	Ave. Monthly Temp. (°C)	-10.9	-13.4	-8.4	4.7	12.3	18.5	20.0	17.0	10.0	5.4	-6.2	-11.3	3.1
	Precipitation (mm)	34.3	15.7	24.3	30.3	39.0	29.7	39.7	34.0	21.0	14.0	13.7	27.0	322.6

3 Previous works

3-1 Previous geological, geochemical and geophysical surveys

3-1-1 Surveys in the Zhaman-Aibat area

Geological surveys

Systematic geological works started in the 1920's The first geological map was made and the Taskura deposit, some 5km west of the Zhaman-Aibat deposit, was discovered. In 1953, the Taskura deposit was explored by drillings which confirmed the rich mineralization located close to the surface. During 1959-1964, exploration parties drilled in the Zhaman-Aibat area and confirmed copper mineralization at the depth of 400-700m with thickness of 0.4-1.0m and copper grade 1.16-1.30%. Essential exploration for copper has been carried out since 1981 by the Zhezkazgan Expedition Party on the eastern flange of the Zhezkazgan-Sarysu depression and confirmed the existence of commercial grade copper and copper-lead mineralization at the depth of 600-700m.

Geochemical surveys

Geochemical surveys (1981 to 1984 and 1987 to 1990) have resulted in delineating mono-element and complex haloes of scattering of chemical elements. 4 big halo areas, namely; Taskura,Zhaman-Aibat, Azat and Zhatyka were delineated.

The Azat halo zone is confined to the central part of the Azat anticline. The set of elements of this halo is different from that of the Taskura and Zhaman-Aibat haloes. However it could be characterized as a zone above ore and at least one prospecting well is recommended to be drilled within the limits of this zone.

Geophysical surveys

In the Zhaman-Aibat area, geophysical reconnaissance and detailed surveys were carried out systematically. In the 1950's a reconnaissance survey was carried out at a 1/200,000 scale, and since the 1970's detailed surveys at a 1/50,000 scale have been started. The surveys utilized are airborne magnetic, ground magnetic, gravity, seismic (reflection wave), and electric (SP, VES, IP, and TEM) methods. At present no other geophysical surveys are planned after the last TEM survey. For exploration of mineralization in this area, the sequence of surveys was seismic followed by gravity and electric. Regional surveys aimed at oil exploration followed a different sequence. Seismic is the most useful method in this area taking advantage of good reflections in a subsurface Carboniferous layer. Electric IP is not a valid method in this area, where the ore horizon is beyond the detection depth. In the Zhaman-Aibat deposit area, geophysical surveys are not necessary in the next year, because this area's exploration is at the stage of exploration drilling.

3-1-2 Surveys in the Samarsky area

Geological surveys

The first recorded prospecting in the "Sarymsak" area dates to 1935 for the prospecting of tourmalized secondary quartzite as a boron resources survey. Gold mineralization was first detected in 1953 with a small discovery of copper (malachite and azurite) in secondary quartzite. From 1954 to 1959, gold and copper exploration was carried out by 4 drillings but no ore could be detected except for dominant haloes of ore minerals.

Geological studies of this territory were completed by 1959 in the scale of 1:50,000 for understanding of stratigraphy, tectonics and metallogenic zoning.

During 1966-1972 Samarsky ore bearing area was systematically prospected and had the conclusion of positive potential for gold and copper.

After summarizing all past data by the Karaganda Geological Expedition (now known as Karagandageologiya), in 1989, the area was again targetted and to complete the geologic map of the central Samarsky copper deposit and surrounding area, mapping drillings (shallow drillings) were carried out. Since 1990 exploration drilling has delineated the ore body of the "Central" Samarsky copper deposit and the "Western" Samarsky gold-polymetallic deposit. A total of 76 exploration holes with the total length of 33,056.2m had been completed by 1994.

Since the autumn of 1994 for checking the deeper geologic structure and confirming the mineralization at lower levels, an additional three drillings were commenced at the eastern limb of the "Samarsky Central Cu deposit"

Geochemical surveys

Geochemical prospecting on secondary haloes has been carried out in the Samarsky area and their surrounding areas since the1950s. More than 30,000 soil samples have been taken since 1957. Spectral analysis made it possible to delineate geochemical anomalies of 23 elements including Cu, Mo, Au, Ag etc. This work has resulted in compiling maps of secondary haloes of 6 representative elements among 13 elements. The results are shown in the Plate Ⅲ-2-3-6.

They characterized geochemical properties of the area and made it possible to evaluate prospects. In the central area, a Cu halo outlines a ring shaped structure centering on an intrusive bodies. A Series of small linear halos are associated with Au and polymetallic anomalies located in the outer zone from the Cu anomaly zone.

Geophysical surveys

In the Samarsky area, the first geophysical surveys have recently begun to check a geochemical anomaly identified in the northern part of this area. Large scale, regional reconnaissance surveys have not finished in the Samarsky area. The surveys that have been utilized are ground magnetic, gravity, and electric (SP, IP, and TEM) methods at scales of 1:50,000 and 1:10,000. Magnetic is the most useful method taking advantage of the magnetic property of the intrusive rocks, strictly related to their mineralization. Electric IP surveys identified gold-polymetallic mineralization zones in the north-west part of the area. At present, results at a 1:10,000 scale are still being updating in the Karaganda office. The central Samarsky area has been regarded as prospective for copper ores and it is recommended for detailed geophysical surveys. The northwest part of the area is also recommended for a detailed geophysical survey especially for the study of the shallow structure bearing gold-polymetallic ore.

3-2 Geologic Setting

The regional geological maps (Figure I-3-2-1 and Figure I-3-2-2) show the principal geologic and tectonic trends of the Zhaman-Aibat and Samarsky areas and their surroundings.

3-2-1 The Zhaman-Aibat area.

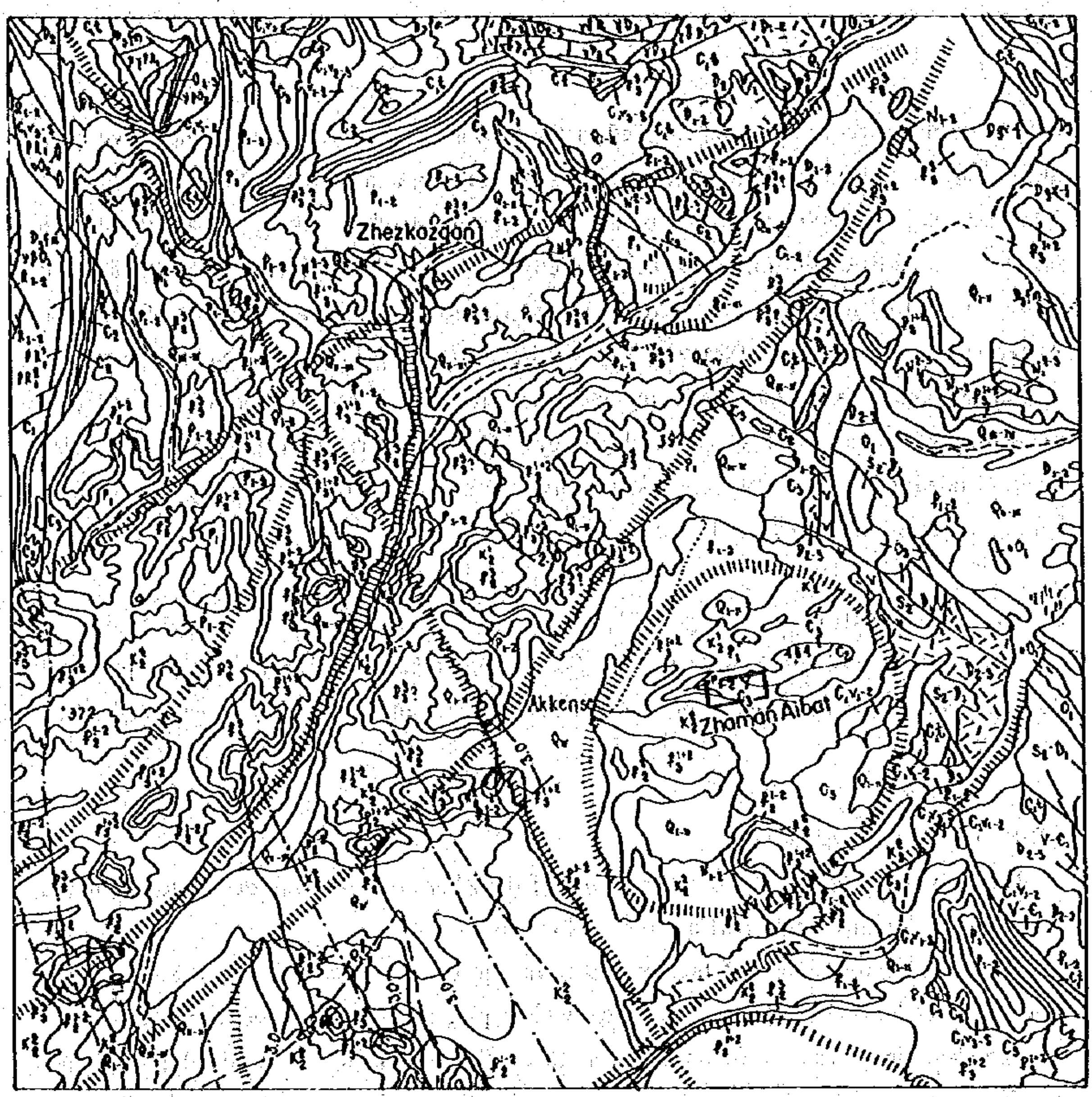
The area is positioned at the eastern flank of the Zhezkazgan-Sarysu depression which is located in the south-western part of Central Kazakhstan.

The geologic formations of the area range in age from the Cambrian to the Quaternary and include sedimentary, igneous, plutonic, metamorphic rocks and younger sediments.

The Cambrian rocks are found in the north-western area in the Ultau anticlinorium area which is composed of gneissose and granitic rocks. The Ordvician rocks are distributed in the north-eastern part of the area and are mainly sandstone and shale with lenses of limestone.

The Devonian formations are widely distributed in the north-eastern area. A thick layer of conglomerate occurs at the bottom and sandstone, aleurolite and lenses of limestone occur at higher positions.

Rocks of the Carboniferous system are widely distributed in the area. Carbonate and terrigenous complex of marine sediments is referred to as the lower and a complex of various sediments of continental origin is referred to as the middle. The group of sediments deposited under the evaporite environment is referred to as the upper



LEGEND

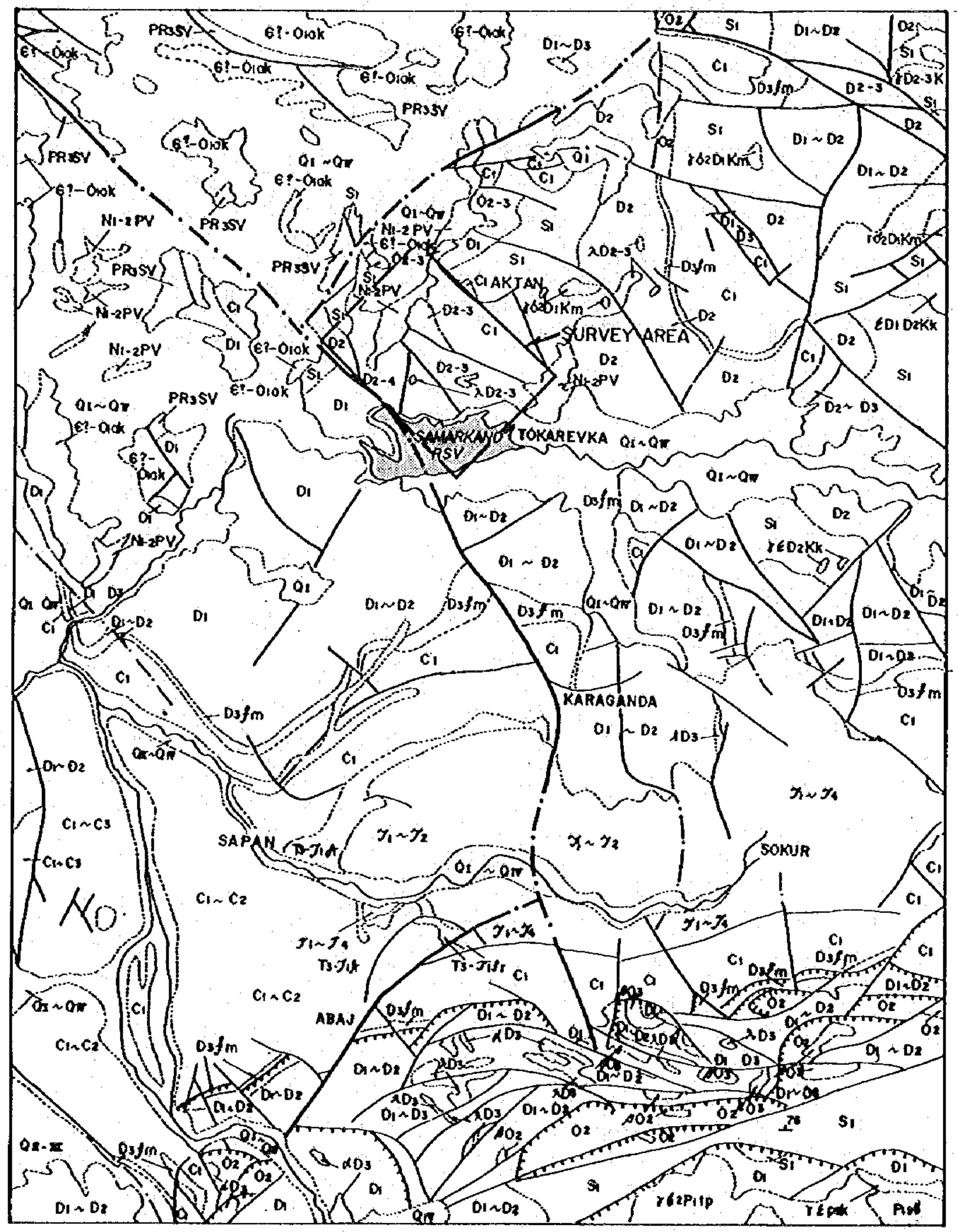
0 15 30 45 60 75 km

Q1+IY	Quaternary
N1'2	Neogene
P1'3	Paleogene
K	Cretaceous
P1'2	Permian
C3	Upper Carboniferous
C2	Middle Carboniferous
C1V-3	Lower Carboniferous; Serpukhov Stage
D	Devonian
S	Silurian
O	Ordovician
€	Cambrian

	Boundary of formation
	Boundary of contemporaneous meteropic facies
	Boundary of tectonic zone
	Thrust fault
	Equi-contour line of base of blanket layer
	Tectonic zone
γβ	Gabbro
δ	Serpentinite, dunite
β	Diabase, diabase-porphyry
// γ	Acidic efusive rocks
V V V	Intermediate efusive rocks
	Zhaman-Aibat Area

Figure I-3-2-1 Regional Geological Map of the Zhezkazgan Area

Ministry of Geology (1982)



Ministry of Geology (1981)

0 10 20 km
1:500,000

Figure I-3-2-2 Regional Geological Map of the Samarsky Area

QI~QIV	Upper~Lower Pleistocene
N1-2PV	Miocene - Pliocene, Pavlodar Formation
J1~J3	Middle~Lower division
T3~J1sr	Triassic system, upper division - Retsky stage - Jurassic system. Lower division - Saramskaya Formation.
P1cb	Lower Division. Chubaraygirskaya Formation
C1~C3	Upper~Lower division - Shakhamskaya Formation, Dolinskaya Formation, Karagamdinskaya Formation, Ashlyarikskaya Formation
D3fm	Non-articulated sediments
D1~D2	Middle~Upper~Lower division - Salkintauskaya Formation, Zhandarskaya Formation, Kurolozekskaya Formation, Byotarskaya Formation, Semizbuginskaya Formation, Zharsorskaya Formation
S1~S2	Non-articulated sediments - Yesemskaya Formation, Yermekskaya Formation
O2-3	Middle~Upper division - Baydayletskaya Formation
Є?-O1br	Cambrian system ?
PR1~PR3	Upper~Lower Proterozoic
γξ2P2k	Late Permian, Kokdombaksky Complex : granosienite
γ1P1tp	Early Permian, Toparsky Complex: granite of normal type and associated potassium feldspar-rich type
γδ2P1tp	Early Permian, Toparsky Complex: granodiorite
γD2-3k	Middle-Late Devonian, Korneevsky Complex: granite of normal type and associated potassium feldspar-rich type
λD3:λD2-3	Liparite
αD3	Andesite
βD3	Basalt and diabase
ξD1D2kk	Middle Devonian, Kokkuduktubibnsky Complex: quartzmonzonite,non-articulated
γξ1D2kk	Granosienite
αD2	Middle Devonian, Sub-volcanic bodies: andesite
γβ2D1km	Early Devonian, Karametdimsky Complex: granodiorite
δ1D1km	Quartz diorite, tonalite
βO3	Late Ordovician, sub-volcanic bodies: basalt and diabase
(thick line)	Main faults (developed regionally)
(thin line)	Secondary faults (within folded structures)
(hachured line)	Overlap, upthrusts and faults (dashes indicate direction of dislocation)
(dash-dot line)	Fault in the basement covered by mantle

Carboniferous. The copper mineralization of the Zhezkazgan and the Zhaman-Aibat deposit is associated with a continental alluvial and deltaic red-colored sandstone sequence (middle to late Carboniferous and lower Permian, Figure I-3-2-3). Permian sediments mainly composed of terrigenous and high carbonate content, are widely distributed and are represented by red-colored sandstone and evaporite in the lower and limy sandstone facies with marl in the upper position.

Mesozoic and Cenozoic sediments are widely distributed in the whole area and are represented by aleurolite, sandstone and clay.

Intrusive activities in the Cambrian and the Ordovician ages are mainly plutonic rocks and their distributions are noticed in the Kengir brachi-fold zone. Devonian volcanic and intrusive activities recognized in the northern to north-eastern area are characterized by high variability of facies.

3-2-2 The Samarsky Area

The Samarsky area is located at the marginal Devonian volcanic belt at the junction of the large Caledonide structures; -Erementay-Nyaz anticlinorium, Semizbugin and Shokshan synclinoria (Plate I-3-2-2). Such structural position results in wide development of volcanic, intrusive and volcanogenic-sedimentary formations of Devonian age.

In accordance with the regional stratigraphic scheme, the following stratified divisions have been defined within the area:

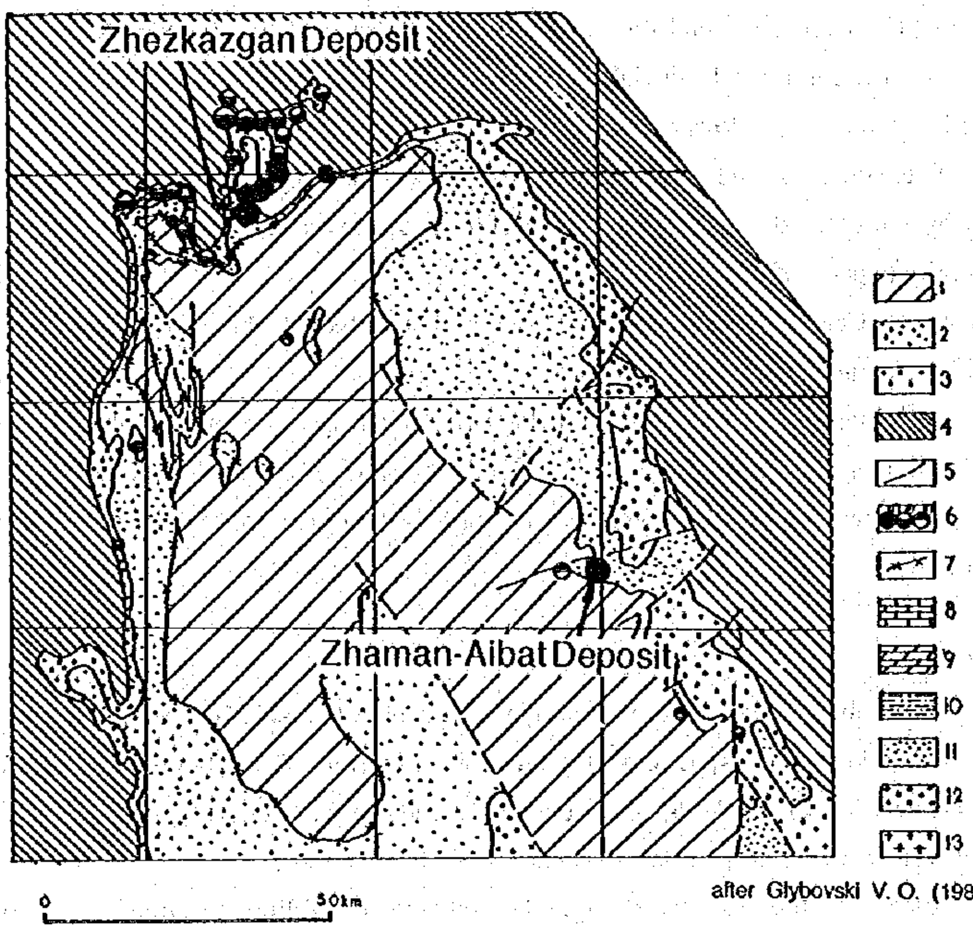
Devonian system is divided into Early Devonian, Lokhkov-Em stage's Zharsor Formation of tuffaceous volcanogenic rocks and Middle Devonian, Zhivet stage's Konyr Formation of volcanogenic sedimentary rocks.

Neogene system is divided into Middle-Upper Miocene, Kalkaman Formation and Upper Miocene-Lower Pliocene, Pavlodar Formation. The Kalkaman Formation is composed of lacustrine, alluvial-lacustrine and diluvial-proluvial clay sedimentary rocks. The Pavlodar Formation is composed of mainly red-brown washed lacustrine, lacustrine-alluvial sandy clay and sedimentary rocks.

Quaternary system is divided into a Lower Layer of lacustrine-alluvial deposits, Middle-Upper Layers of proluvial-deluvial deposits and a contemporary layer of proluvial and lacustrine deposits.

Intrusive formations include Early-Devonian orogenic Karamendin complex, Early-Permian Vishnev and Late-Permian Manybay and Koitas complexes of Epi-Caledonian activity.

The Karamendin complex of quartz diorite, associated with the first phase of intrusion



after Glybovski V. O. (1988)

1 Grey marl deposition of Permian
2 Red rhodusite-gypsum-salt-bearing formation of evaporite type of lower Permian
3 Cuprous red formation of middle and upper Carboniferous
4 Grey terrigenous-Carboniferous depositions of lower Carboniferous
5 Tectonic dislocation
6 Types of mineralization of cuprous sandstone (a-Dzhezkazgan type, b-Dzhilandin type, c-Mansfeld type)
7 Cuprous stratum of Mansfeld type
8 Limestone including flints
9 Marl
10 Alcurolite and argillite
11 Sandstone
12 Conglomerate
13 Gypsum and salt

Figure I-3-2-3 Distribution Map of Stratiform Copper Deposits in the Zhezkazgan-Sarysu Depression Area and granodiorite porphyry of the second phase of intrusion constitute the Tulkulinskaya intrusion, which outcrops in the central part of volcanic-plutonic structure.

The Vishnev complex of quartz monzodiorite, less frequently monzodiorite and granodiorite consists of minor intrusions and dikes, mostly located in peripheral parts of Tulkulin volcanic-plutonic structure and zones of faults.

The Manybay complex is composed of sub-alkaline dolerites, gabbro and gabbro-diorite and includes groups of dikes and minor intrusions, located mostly at axial parts of the Tulkulinskaya volcanic-plutonic structure.

The Koitas complex of rhyodacite-porphyry, rhyolite-porphyry and granite-porphyry is defined conventionally. This complex includes group of dikes and less frequently,minor intrusions, mainly located at the peripheral part of Tulkulin volcanic-plutonic ring structure.

Two types of ore deposits occur in the Samarsky survey area. Both are closely associated with the Devonian volcanism.

In the Northern part of the area, gold-polymetallic type ore deposits are known in the Zharsor Formation in the Dumkorin tectonic section. Mineralization forms gold-bearing lead, zinc deposits in the crushed zone of secondary quartzite and beresite.

The other type of deposit is copper-porphyry which is located in the central part of the area and is known as the Samarsky copper deposit. This deposit is closely connected with the Karamendin complex at the Tulkrin volcanic-plutonic structure. The major ore minerals are chalcopyrite with minor molybdenite and chalcocite impregnated in hydrothermally altered, brecciated, granodiorite porphyry and quartz diorite.

3-3 Mining activities in the surrounding area

3-3-1 The Zhezkazgan region

The Zhaman-Aibat area is located 180 km southeast of Zhezkazgan. The Zhezkazgan area has long been known for its production of copper ore and copper. Historical progress of the Zhezkazgan mine and smelting plant is shown below;

1771; The Russian geographer Captain Richkov described the Zhezkazgan deposit in his "Notes on Antiquites".

1847; The Zhezkazgan copper deposit and the Baikonur coal-mines were purchased by Russian merchants and industrialists, later they became British concessions.

1928; The Atbasar Non-Ferrous Metals Trust was established and incorporated the Karsakpai Combine which amalgamated the copper smelting plant, the Baikonur coal mine, the Zhezkazgan copper mine and the Kurgasyu mine.

1929-41; Kanysh Satpaev supervised the prospecting of the Zhezkazgan copper deposit.

1936; Decided to construct the Zhezkazgan copper smelting plant.

1937; Connected with nationwide railway network.

1943; Organized the Zhezkazgan Combine which comprised 17 mines, 3 open pits, the Karsakpai copper smelting plant, Baikonur coal mine, etc.

1945-55; Built new mines and put into operation; Petre-Center, Pokro, Nos.3,42,44,45,51; the open pits Karpiev, Nikol, Krestov, Moly Zlatoust and an ore dressing factory.

1958; An excavator, electric dump-truck and four-puncher boring machine were introduced to operate in underground mine No.45.

1963,1965; Commenced the first cycle and the second cycle of No.2 Ore-Dressing facility operation.

1965-67; Commenced operation of Giant Mines No.55 and No.57.

1975; Commenced operation of No.65 Mine.

1977; Commenced operation and production of the whole copper-smelting plant.

1985; Commenced operation of No.67 Mine. Reorganized the Satpaev Zhezkazgan Mining

Smelting Combine into the Satpaev Scientific and Production Management, Zhezkazgantsvetment.

1995; 4 mines (1 open-pit mine, 3 underground mines) are being operated and 1 mine is under development. 2 ore dressing plants and 1 copper smelting plant are also being operated. The total annual production of electrolytic copper is approximately 200,000 tons.

3-3-2 The Karaganda region

There are no metal mines currently in operation in the Karaganda region which includes the Samarsky survey area. The region is however famous for coal production and several quarries supply building stone for local construction.

Coal deposits were first discovered in 1833 and have been continuously mined since 1857. Coal production has steadily expanded since the Soviet Union introduced modern mining techniques to the region in the 1930's. By 1962 the Karaganda region was producing 11,720 tonnes of coal per day and was the largest producer of coal in the USSR.

Since 1962 many of the old facilities have been reconstructed and new mines opened representing an investment of some 350 million rubles. Mines produce mainly coke which is supplied to more than 30,000 consumers including major industrial cooperatives, power stations and other industrial facilities.

4 Survey results and discussion

4-1 Survey results

4-1-1 Remote-sensing data analysis

Photogeological interpretation of satellite images

In the analysis of satellite images of the Zhaman-Aibat area (Figure I-4-1-1), the following photogeological parameters were observed, extracted and analyzed for the interpretation of topography, water courses, geology, geologic structure and alteration. The photogeological characteristics of color, lightness, shade, texture, pattern, form and size were observed and used to classify topography, geological structure, geologic stratigraphy and others.

By the photogeological analysis, the Zhaman-Aibat area was classified into three topographic categories of desert, low plane and low hills (with three sub-categories).

Geological classification (corresponding to stratigraphy) of the target area was distinguished as 10 geologic units and subunits. Referring to published geologic maps, these geologic units correspond to Permian, Cretaceous and Quaternary systems. The Carboniferous system described in the maps was not however distinguished in the satellite images (Refer to Plate II-3-1-1 and Table II-3-1-1).

The major geologic structure in the area is the asymmetric anticlinal structure located in the central part. Its axis has a direction of east-north-east and plunges to the west-south-west. Some faults cut the anticline and two other incomplete circular structures were also extracted in the image.

Satellite image data processing

Satellite data from Landsat TM5 scenes (Path 155, Row 027 and Path 155, Row 028) were used for the satellite image analysis in the Zhaman-Aibat area. The processing method involved generation of color composite images and color density slice maps in order to distinguish alteration zones. Three processed color areas (Figure II-3-2-1) are associated with the Zhaman-Aibat horst anticline; a blue area spreads as a triangle-form to the west of the horst, a reddish purple area surrounds the horst in a semicircle, and the rest of the area is yellowish green. The blue area identifies iron oxide and iron hydroxide that contains coincides with the "red sandstone". The reddish purple area corresponds to Quaternary sediments surrounding the Zhaman-Aibat horst anticline. The yellowish green area corresponds to weathered layers of Quaternary and Cretaceous age.

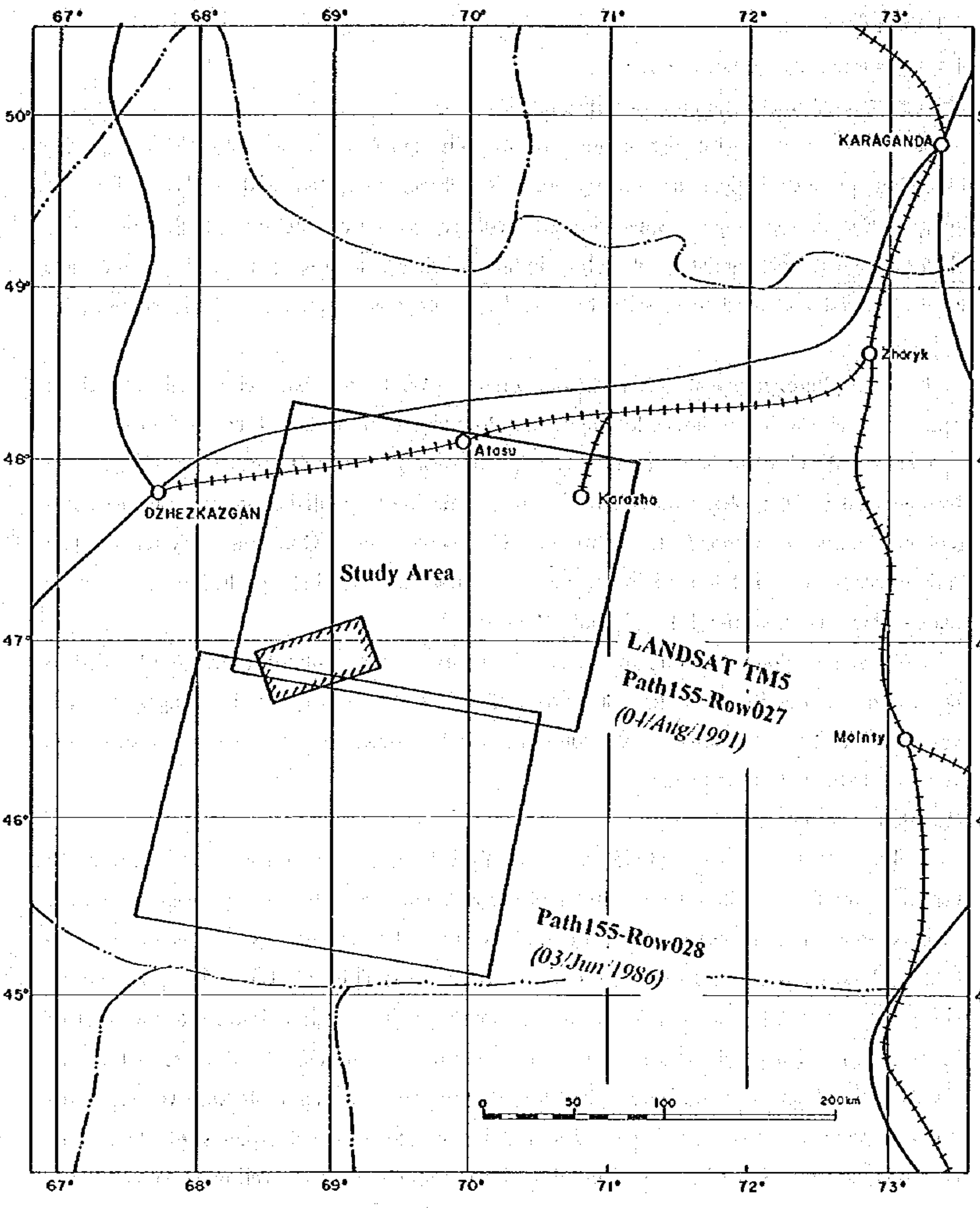


Figure I-4-1-1 Location Map of Satellite Image Analysis in the Zhaman-Aibat Area

4-1-2 Geology and Ore Deposit

The Zhaman-Aibat area

(1) The Zhaman-Aibat copper deposit is located at the eastern edge of the Zhezkazgan-Sarysu depression (Figure I-3-2-3). The stratiform copper mineralization occurs exclusively in the grey colored alluvial-deltaic sandstone facies within "Red Sandstone Formation" that range in age from the middle to late Carboniferous and the early Permian (Table I-3-3-1).

(2) More than 800 drillings on a 200m×200m grid-spacing confirm that there are three main orebodies, namely, the Central, Northern and Eastern Orebodies. These orebodies are distributed in an area with dimensions: 12.5km in the east-west direction and approximately 5km in north-south direction. The depth of the ore horizon is approximately -400m~-500m in the eastern area and the depth increases toward the west. At the western edge of the Central Orebody it reaches -700m~ -750m.

(3) Ore minerals are mainly chalcocite and bornite accompanied by small amounts of chalcopyrite. Rare occurrence of galena, sphalerite, tennantite, digenite and native silver are observed. With the assemblage of these minerals, four ore types, namely, Cu Ore(Cu), Complex Ore(Pb+Zn+Cu), Pb-Zn Ore(Pb+Zn) and Ag Ore(Ag+Cu) are classified.

(4) 10 mineralized horizons are reported in the sandstone formation of the Carboniferous Age. However, only a few mineralized horizons are commercially interesting and are considered to be promising for future mining. In particular the horizon 4-I is rich in copper content with thick ore layer and is the main part of the Zhaman-Aibat copper deposit.

The Samarsky area

(1) It is confirmed that there are two types of ore deposit, porphyry type copper-molybdenum deposit and gold-bearing polymetallic deposit. These deposits show zonal distributions centered on copper-molybdenum zones (Table I-3-3-2).

(2) Porphyry Copper-Molybdenum Deposit

① Porphyry type copper-molybdenum mineralization occurs in breccia pipes which were formed within the intrusive bodies of the quartzdiorite in early stage and in the granodiorite porphyry in later stage, which intruded the andesite~basalt lava, their pyroclastics and sedimentary rocks of the early Devonian in age.

② Among the ore minerals, the main primary copper ore mineral is chalcopyrite accompanied by rare occurrences of chalcocite and bornite. On the other hand, in the secondary copper minerals malachite is predominant and chrysocalla and azurite are rare.

Table I-3-3-1 List of Ore Deposits and Ore Showings in the Zhaman-Aibat Area

Name of Deposit	Zhaman-Aibat	Taskura
Type of Deposit	Stratiform-Cu	Stratiform-Cu
Ore Type	Cu, Pb, Zn, Ag	Cu
Dimension	12.5km(EW)x 5km(NS)	0.3km(EW)x 0.3km(NS)
Depth	-400 m ~ -700m	0 m ~ -30m
Ore Grade	1.8 % Cu 9.2 g/t Ag	1.0 - 1.3 % Cu
(million t.) Ore Reserve	200 million tons (cut-off 0.4%Cu)	7 - 9 million tons
Ore minerals	chalcocite bornite chalcopyrite galena sphalerite	chalcocite bornite chalcopyrite malachite

Table I-3-3-2 List of Ore Deposits and Ore Showings in the Samarsky Area

Name of Deposit	Samarsky Central	Samarsky North	Samarsky West
Type of Deposit	Porphyry-Cu	Porphyry-Cu	Au-polymetallic
Ore Type	Cu, Mo	Cu, Mo	Au, Pb, Zn
Dimension	500(NE)mx400m(NW) 2000mx1500m(Max.)	400m x 250m	700m(NS)x250m(EW) Ave. thick. 8.6m
Depth	-50 m ~ -600m+	~ -600m(?)	0 m ~ -350m
Ore Grade	1.28 % Cu	not calculated	3.8 g/t Au 20.0 g/t Ag
(million t.) Ore Reserve	200 million tons (cut-off 0.4%Cu)	not calculated	5.6 million tons
Ore minerals	chalcopyrite chalcocite molybdenite malachite	chalcopyrite chalcocite molybdenite malachite	galena sphalerite native Au

③ The oxidized zone is confirmed to the depth of -30m～-50m and the primary sulfide zone starts from this depth and continues to greater depths. Secondary enrichment zones have not been reported. The high grade zone of greater than 1.0% Cu is exclusively foundwithin the breccia pipes mentioned above. Thus the shape of the high grade copper orebody represented by that of breccia pipes. The actual shape of the orebody shows the increasing diameter towards greater depth.

④ The hydrothermal alteration shows that propylitic alteration forms a ring structure with a potassic alteration zone at its center. The argillic alteration zone is located in the outermost part of the hydrothermal alteration zone. Both the potassic and propylitic alteration zones are observed at depths greater than -500m～-600m. On the surface, propylitic and argillic alteration are widely distributed.

(3) Gold-bearing Polymetallic Deposit

① Gold-bearing polymetallic deposits ore located in the outer rim of the porphyry copper-molybdenum deposit, and are distributed in the sheared zone of the hanging wall side of thrusts running in the north-south direction in the north-western to western part of the survey area. The previous survey confirms that there is one main ore vein and three branched veins.

② By the results of the drilling exploration, the vein of gold-bearing polymetallic deposits strikes in the north-south direction and dips 35°～50° to the west. The average thickness and ore grade are estimated to be respectively 5.6m and 3.82 g/t Au and 20g/tAg. It is confirmed that the ore zone continues approximately 800m along the strike direction and 1,000m along dipping direction, which means that mineralization is confirmed to a depth of -350m below the surface.

③ Ore veins consist of mainly quartz accompanied by galena, sphalerite, chalcopyrite. Gold occurs as native gold in quartz veins and some in galena, chalcopyrite and pyrite.

④ Hydrothermal alteration is sericitization, carbonitization, argillization and silicification in character.

4-1-3 Ore reserve estimation

The Zhaman-Aibat copper deposit

This year, the geological ore reserve for the Block-A in the Eastern Orebody was calculated by the Japanese survey team and was compared to the reserve estimated by Zhezkazgangeologiya. The calculation was based on the data entered into the data-base of the Zhaman-Aibat ore deposit. The total number of the data entries in the data base is 2,862 from 305 drill holes and of these a total of 1996 data entries from 115 drill holes were used for the calculation.

The block was delineated by the cut-off grade of 0.4%Cu. The ore bearing formation in Block-A is limited to the 4-I horizon. The plane boundary of the block is delineated by the bisectors between ore penetrated drill holes and those that have not intersected the ore body.

The Zhezkazgangeologiya calculated the ore reserve by multiplying the total plan area and the average thickness of ore section in the drill holes. In the calculation they used the conventional value of 2.60 as the average density of ore.

The Japanese survey team calculated the ore reserve by the polygon method. In order to compare the ore reserve estimate, the Japanese team adopted the same boundary, cut-off grade and density as the Zhezkazgangeologiya. The result is listed in Table III-1-4-1.

By comparing the geological ore reserves of Zhaman-Aibat in the table calculated by Zhezkazgangeologiya and by the Japanese survey team, it can be seen that the overall trends are rather similar. The area of Block-A calculated by the Japanese survey team is 3,365,326m^2 (97.6% of 3,447,426 m^2 of Zhezkazgangeologiya) and the average thickness is 5.45m (105.2% of 5.18m). Then the volume of the ore body is 18,346,112 m^3 (102.7% of 17,857,668 m^3). Multiplying the conventional value of density, 2,600 (same value used by Zhezkazgangeologiya) the total ore reserve is calculated as 47,699,892t (102.7% of 46,429,900t).

The Japanese survey team calculated the average copper content as 1.84%Cu (102.2% of 1.80%Cu) and the copper metal amount as 876,883t (104.9% of 835,700t).

But with regard to the chemical analyses the Japanese check analysis showed a big discrepancy with the results obtained by Zhezkazgangeologiya (Table III-1-4-2 and Table III-1-4-3). The Zhezkazgan value is +7.6% higher on average than the Japanese check analysis. Because this discrepancy is unacceptable, it is important that all processes of the Zhezkazgangeologiya analysis be checked and the ore grade and metal amount of Block-A recalculated using reliable figures.

The Samarsky copper-morlybdenum deposit

Until now 12 exploration drills have penetrated the copper ore in the Samarsky Central area. The Karagandageologiya delineated the ore body by the cut-off grade of 0.5%Cu and calculated the ore reserve estimation by the conventional panel/section method.

To estimate the ore reserve independently, the Japanese survey team used the same procedure based on the data entered on personal computers by the team. The data entries were the preparation for the construction of a database for the Samarsky copper deposit in the cooperation project. The result of the ore reserve estimation is listed in Table III-2-4-1.

By comparing the geological ore reserves of the Samarsky area as calculated byKaragandageologiya and by the Japanese survey team, it can be seen that the overall trends are rather similar.

In the estimation by the Japanese survey team, the total area of the Samarsky ore block panels is 378,838m² (99.0% of 382,663m² of Karagandageologiya). Then the volume of the ore body is 41,447,469m³ (101.8% of 40,729,933m³). Multiplying the conventional value of density, 2.76 (same value) the total ore reserve is calculated as 114,395,015t (101.8% of 112,414,616t).

The average copper content is 1.28%Cu (102.8% of 1.24%Cu) and the copper metal amount is 1,458,777t (104.4% of 1,397,806t).

In the estimation of geological ore reserves some problems have been indicated of which the most important problem is the number of drills. The number of drill holes that penetrate the ore body is only 12. It is too few to delineate the ore block precisely. The continuity of the ore block is therefore very uncertain at present.

Another problem is the estimate of ore density. Measurements of ore density should also consider the pyrite content of the ore.

The reliability of chemically analyzed values of each element is another major problem. In Zhaman-Aibat samples the discrepancy is unacceptably large and suggests that a similar check analysis should be performed for the Samarsky deposit.

4-2 Discussion

4-2-1 The Zhaman-Aibat area

(1) From satellite image interpretation, the most important geologic structure is the anticlinal structure located in the central part of the area. Its axis has a direction of east-north-east and plunges to the west-south-west. Anticlinal structure is asymmetric with the south wing being more gently sloped than the north wing. The axis in the east-northeast direction is cut and shifted by the cross faults with north to south strike (direction).

The satellite image processing method involved generation of color composite images and color density slice maps in order to distinguish alteration zones. A color ratio composite image extracted characteristic color areas. A blue area coincides with the red sandstone, which contains iron oxide and iron hydroxide. According to the fact that the red sandstone contains ores, the blue colored area is a valid target in peripheral sedimentary rocks in the survey area. In next year's study it is necessary to do a spectral analysis of rocks and to make a ground truth checking in geologic units.

(2) An ore reserve estimation of "Block-A" of 4-I ore horizon of the Eastern Orebody was carried out by using 217 drilling data and 1996 chemical assay data and by adopting the

polygon method. As a result, it is concluded that the geological ore reserve is approximately 84 million tons with an average copper grade of 1.8% (cut-off copper grade 0.4%) and an average thickness of 5.45m. The differences between the result of the Zhezkazgangeologiya estimation and that of Japanese survey team are reasonably small and the results are in agreement.

(3) The ore reserve estimation carried out this year, is categorized to be "geological ore reserve" and not to be "minable ore reserve" (this estimation work is scheduled in 1996). It is expected that after considering the practicalities of the actual mining operation, both the ore reserve and average grade estimates will decrease.

(4) By the previous drilling exploration using a 200mx200m grid pattern, drillings cover the huge Zhaman-Aibat ore deposit area. A new 100mx100m grid pattern with 1,300 drillings is scheduled to start in the future. However, no study of the necessity of such an amount of drilling has been done. It is recommended to study the appropriate drilling spacing by the geostatistical approach.

(5) Comparing the analytical results obtained by the Zhezkazgangeologiya laboratory with these obtained by the Japanese laboratory, the former is significantly higher in copper contents. The discrepancy between the two laboratories is so significant that a thorough verification of the existing analytical data is required. No correction has been made for the existing analytical data in the ore reserve estimation in this year's campaign.

(6) The works currently required for this area, from preparing the assay data sheets to out putting the results of the ore reserve estimation, require a huge amount of manpower. At present, all this work is being done by hand with the result that there are many duplications, confusion and mistakes in the data sheet. The reliability of data is inevitably reduced. Therefore, it is necessary to review all the data sheets and to reassemble them and to adopt a computer system for the management of data and to progressively update it.

4-2-2 The Samarsky area

(1) Satellite image processing methods were successfully used this year to distinguish alteration zones in the Zhaman-Aibat area. As alteration is an important feature of the Samarsky area, it is necessary that satellite image processing be applied in this area next year to help delineate alteration zone.

(2) From the results of 46 drillings with a total drilling length of 27,976m, 12 drilling data and 937 chemical assays of copper, molybdenum, gold and silver were used for the ore reserve estimation the Sarmarsky Central Area. The results show the geological ore reserve (not minable ore reserve) is estimated to be 114 million tons with an average copper grade

of 1.2% (cut-off copper grade 0.5%), accompanied by an average grade of 0.48 g/t Au and 0.01%Mo.

(3) The ore reserve estimation was carried out by the panel section method. The estimation procedure included the following problems. The most serious problem is the limited number of drillings which reduces the accuracy of the continuity and delineation of the ore zone and of the ore reserve estimation itself. It is finally concluded that the overall accuracy of the ore reserve estimation of this year's campaign is low.

(4) Due to the deeper location(-300m below the surface) of the high grade part of the copper mineralization, it is expected that there will be some difficulties in the actual mining operation in the future. At present, in the eastern part of the previously surveyed area, the second breccia pipe accompanying high grade porphyry copper-molybdenum mineralization is being drilled to shallower depths. The future exploration should focus on the delineation of the intrusive bodies and confirmation of the breccia pipes. Actual exploration which combine geophysical surveys, such as electric survey(charge potential survey), seismic survey(reflection wave method) and drillings, are recommended. Drilling in the following candidate areas is also recommended:

① the eastern marginal area of the quartz diorite intrusive body,

② in the areas surrounding the breccia pipe located, about 1km southeast of the known orebody, and

③ in the area between the known orebody and the Tulkulin fault.

5 Conclusion and recommendations

The result of the present study lead to the following conclusions.

(1) Zhaman-Aibat copper deposit and the Samarsky copper-molybdenum deposit and gold-bearing polymetallic deposit represent resources that are essential to the economy of the Republic of Kazakhstan. It is recommended to proceed not only with the exploration of new ore deposits but also the evaluation of the known, unexploited deposits.

(2) The Zhaman-Aibat copper deposit is a type of stratiform copper deposit, and has many analogies to the Zhezkazgan copper deposit. Technologies, such as mining, ore dressing, smelting will be applicable to the exploitation of the Zhaman-Aibat copper deposit. Thus it is recommended to study the appropriate drilling interval, future mining method and to check chemical assay methods and results in the early stages before the evaluation of the deposit scheduled in 1996.

(3) The known deposit (orebody) of porphyry copper-molybdenum in the Samarsky area, is located at the deeper levels. Considering the future mining, the copper-molybdenum

mineralization at the shallower depth and gold-bearing polymetallic deposits in the candidate survey area should be surveyed.

(4) At present, all works from assay data sheet preparation to the ore reserve estimation are done by hand and produce several data sheets. Errors, omissions and inconsistencies in the hand written data sheets reduce the reliability of each data. It is recommended to adopt a computer system for the management of exploration data.

(5) At the Zhaman-Aibat deposit, since the areal extent of the ore zone has been confirmed, the exploration stage is advancing to the higher stage. Thus no geophysical survey is needed in this area. On the other hand, in the Samarsky copper-molybdenum deposit and the gold-bearing polymetallic deposit, much exploration, such as geophysical surveys, drilling, etc., are needed not only in the surrounding areas of the known deposits but also in the new candidate areas.

Based on the results, it is recommended to carry out the following exploration works for the 1995 campaign.

(1) Remote-sensing analysis

Remote-sensing data analysis and ground truth checking (surface geological survey) in the Samarsky area.

(2) Study and evaluation of the previous survey data.

In particular, the following data evaluations are needed:

① Data on the Eastern and Central orebodies in the Zhaman-Aibat copper deposit.

② Data on the Samarsky copper-molybdenum deposit, gold-bearing polymetallic deposit and their surrounding areas.

(3) Geophysical Surveys

① Electric survey (charged potential method), in order to detect subsurface conductive bodies of copper-molybdenum deposits accompanying intrusions.

② Seismic exploration (reflection wave method) to study geological structures at the vicinity of gold-bearing polymetal zone.

(4) Drilling Exploration

It is recommended to drill on the exploration of:

① Distribution of intrusives and breccia pipes at shallower depth, related to the Samarsky copper-molybdenum deposit, the southern extension and the deeper mineralization of the known gold-bearing polymetallic deposit.

② Basic data gathering in the Zhaman-Aibat copper deposit.

(5) Ore reserve estimation

Construction of the data base for the evaluation of the deposit.

① Data input

Zhaman-Aibat deposit: data on the Eastern and Central Orebody, approximately 300 drill hole data sets.

Samarsky deposit: data on the porphyry copper-molybdenum deposit and the gold-bearing polymetallic deposit, approximately 80 drillhole data sets.

② Ore reserve estimation

Zhaman-Aibat deposit: the Eastern and Central Orebody

Samarsky deposit: porphyry copper-molybdenum deposit, gold-bearing polymetallic deposit.

PART II
REMOTE–SENSING DATA ANALYSIS

PART II REMOTE-SENSING DATA ANALYSIS

1 Remote-sensing data

The target area for satellite image analysis is the Zhaman-Aibat area (1,800 km²) in Central Kazakhstan, outlined in Figure I-2-1-1.

The area belongs to the continental climate zone in which summer are short and in winter season is very cold. The vegetation in the area is very thin. The topography in the area is very gentle and is classified as "peneplane stage". The major part of this area represents hills and slopes and low planes are located only in the north-western part of the target area.

The analysed satellite data are from two scenes of Landsat TM shown in Figure I-4-1-1. Satellite images used for the photogeological analysis are two false color images; one scene is a band combination of 1(blue), 4(green) and 5(red), the other is a combination of 4(blue), 5(green) and 7(red). The digital data of six bands of 1,2,3,4,5 and 7 were used for the digital data processing for the extraction of alteration zones.

Table II-1-1 List of Remote-sensing Data used in the Analysis

Path No.	Low No.	Date
155	28	03/Jun./1986
155	27	04/Aug./1991

2 Method

2-1 Photogeological analysis

For the geologic interpretation by photogeological methods it is necessary to identify the photogeologic parameters and factors and to translate these factors to geographic, botanic and geologic phenomena. Because the satellite image used in this analysis has no stereographic image, the topography, water system, geology, structural geology, alteration and so on were interpreted by single photogeological observations.

In the analysis the following factors were observed, extracted and analyzed.

(1) Photogeological character

① Color classification

② Texture (very fine, fine, medium, rough)

(2) Analysis of topographic parameters

① Water system (pattern, density and others)

② Topographic pattern

③ Structural topography (degree of stratification)

(3) Analysis of geological structure

① Strata and folding (inclination, strike)

② Fault and lineament (relation of crossing, sense)

③ Ring, basin and other structures

(4) Analysis of geology

① Surface texture classification (rock faces)

② Similar surface distribution (distribution of a rock type)

③ Geologic unit classification

④ Alteration zone

(5) Others

For the photogeologic observation and interpretation of these factors in the satellite image, the following parameters were adopted to analyze each factor;

(Note: the effect or influence of vegetation was rather weak in the satellite images in this area).

The distinguishing parameters obtained from photogeological observation are hue, lightness, shade, texture, pattern, form, size and others. Photogeological observation was carried out to observe these parameter individually or in combination.

Of these parameters, hue is the most important and useful parameter and when combined with lightness it is effective in detecting regions of similar rock type. In fact the combination of hue, lightness and saturation (chroma) in the analysis is a very powerful method to identify similar rock types. In the case of satellite images the hue is that of false color, and by selection of suitable combinations of each color band precise interpretation for recognition of a particular target is possible.

The lightness is the most primitive parameter used to detect regions containing the same characteristic. Even if the photograph is mono-chrome, lightness provides much information; for example, it is useful in interpreting the inclination of a plane (surface) in the topography.

The texture of the surface is basically the reflection of minute (infinitesimal/ microscopic) changes (variation/transition) in the image, and if the frequency is below the limit of detection for the observer the change is observed as smoothness in the image as the class of coarse (or rough) to fine-grained. And the dimension of frequency to repeat gives the different pattern information as uneven, smooth, (equi-and unequi-)granular to the observer.

In satellite images, the photograph is an accumulated image of pixel data, therefore the texture precision (pitch/size) depends on its resolution and on the minimum size of frequency pitch is the same as the unit pixel size. The smaller data is buried in a single pixel and cannot be detected in such a case.

The pattern parameter is a larger scale phenomenon reflecting the larger, regularly repeated arrangement on the ground surface. One of the most common patterns is a lineament which can be classified as straight, curved or meandered, and by its length, and in combination they can be classified as parallel, radial, crossing (at right angles, oblique, rectangle, grid, network), circular (concentric), arborescent or irregular/random arrangement. Especially for the interpretation of eroded topography pattern of water courses and others carved (engraved) on the surface, the parameter of pattern is the most important factor. Patterns of vegetation or artificial structures (building, road, plant, farm, afforestation and others) also cannot be regretted in interpretation.

Vertical enhancement by the effect of shade (shadow) is an important parameter for topographic analysis. This information comes not only from the uneven surface of the ground but also from the difference of vegetation, water content (saturation/porosity) of the vegetation or underground geological structure or rock faces in some case. It was therefore an important parameter for this photogeological analysis especially in the absence of stereographic information of satellite images.

The size parameter can be used with each parameter described above. By the measurement of size some useful information can be derived. For example, the thickness of water course indicates the porosity of rock or soil and/or composing grain size.

By combining these parameters the photogeological observation and interpretation effectively provided information about topography, water system, geologic structure, geology and stratigraphy.

2-2 Satellite image data processing

Satellite data from Landsat TM5 scenes (Path 155, Row 027 and Path 155, Row 028) were used for the satellite image analysis. An analysis area was selected as a subscene contained within the two scenes and including the Zhaman-Aibat area. Image processing and analysis were carried out on a VAX6310(DEC) computer using the DeAnza IP9527 (DOULD) owned by Sumitomo Metal Mining Company.

The spectral data are as follows; bands 1, 2, and 3 are in the visible region, band 4 is centered at 0.85 micro.m, band 5 is centered at 1.6 micro.m, band 7 is centered at 2.2 micro.m, and band 6 is in the thermal region.