An Introduction to the Jabiluka Project: Regional and Mine Geology of the Unconformity-type Uranium Deposit at Jabiluka, Northern Territory, Australia

by

C. J. NUTT and R. I. GRAUCH

Open-File Report #83-163

An Introduction to the Jabiluka Project: Regional and Mine Geology of the Unconformity-type Uranium Deposit at Jabiluka, Northern Territory, Australia

By

C. J. Nutt and R. I. Grauch

INTRODUCTION

The Jabiluka project is a detailed study of the Jabiluka unconformity-type deposit in the Northern Territory, Australia. Estimated reserves of the deposit are 228,000 short tons of U_3O_8 at 0.39 wt percent U_3O_8 uranium and 350,000 oz. of recoverable gold (Hegge and Rowntree, 1978, Rowntree and Mosher, 1976). The study is focused on 1100 samples collected from 19 core holes which were logged by the authors at the Jabiru Camp. Pancontinental Mining Limited of Sydney, Australia, kindly gave us access to the core and made their geological and geophysical data available for inclusion in this report. Sampling was done along a longitudinal section through Jabiluka 1 and Jabiluka 2 (fig. 1). A similar and concurrent study on Ranger, another unconformity-type deposit in the Northern Territory, is being conducted by J. T. Nash and David Frishman of the USGS.

The study of unconformity-type deposits--major sources of uranium that were discovered in the past 15 years in Australia and Canada--was part of the U.S. Department of Energy National Uranium Resource Evaluation (NURE) program. Data and interpretations from these two projects should aid in defining characteristics and settings of these world class deposits and guild exploration for similar deposits in the United States.

This report on the regional and mine geology at Jabiluka contains the information needed for more detailed studies on the ore-bearing sequence. The geologic descriptions are from published and company data. The regional geology is from Needham and others, 1980; Needham and Stuart-Smith, 1980; and Hegge and others, 1980.

REGIONAL GEOLOGY

The Jabiluka deposit is located in the Pine Creek geosyncline, Northern Territory, Australia (fig. 2). The Pine Creek geosyncline consists of about 14 km of Lower Proterozoic metasedimentary and subordinate metavolcanic rocks overlying Archean complexes which are exposed as granite-gneiss domes. Metamorphism of the geosyncline region at about 1800 m.y. was to greenschist facies in the west and amphibolite facies in the east. Multiple folding episodes accompanied the more intense metamorphism. Middle Proterozoic or younger, essentially undeformed, sedimentary rocks overlie the metasedimentary sequence.

Igneous activity preceded and followed metamorphism. Sills of the Zamu Dolerite were intruded near the end of sedimentation and were subsequently metamorphosed along with the enclosing sedimentary rocks. Granitic intrusions dated at about 1870 m.y. (Page and others, 1980) may have signaled the onset of metamorphism and were themselves affected by the 1800 m.y. event. Granitic plutons and continental tholeiitic lopoliths 1688 ±19 m.y. of the Oenpelli Dolerite post-date metamorphism (Page and others, 1980).

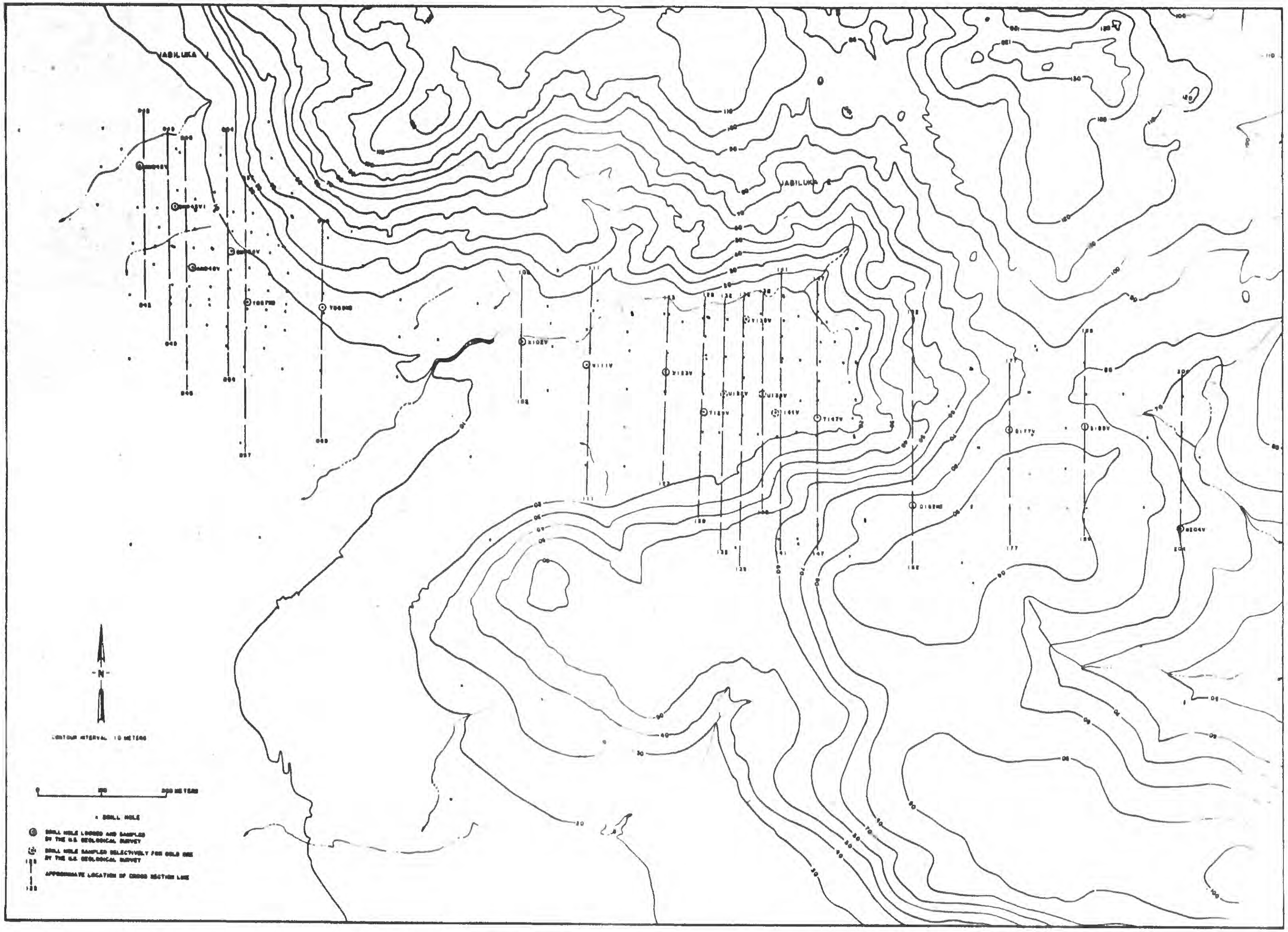


Figure 1.--Drill hole and cross section line localities at Jabiluka, modified from Pancontinental Mining Limited map.

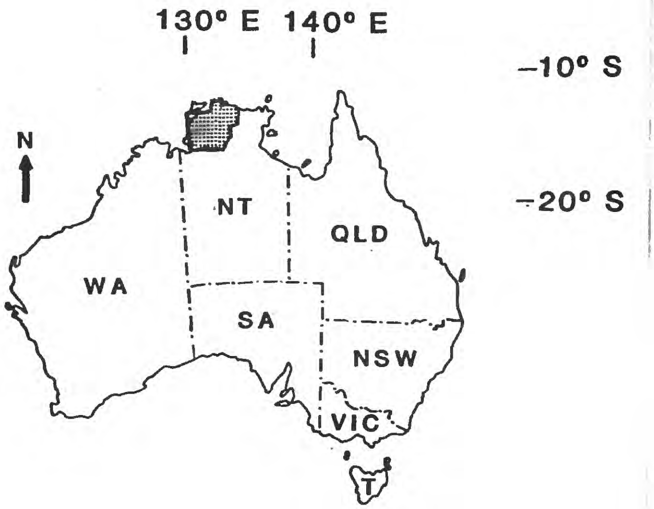


Figure 2.--Locality map of the Pine Creek geosyncline in the Northern Territory, Australia.

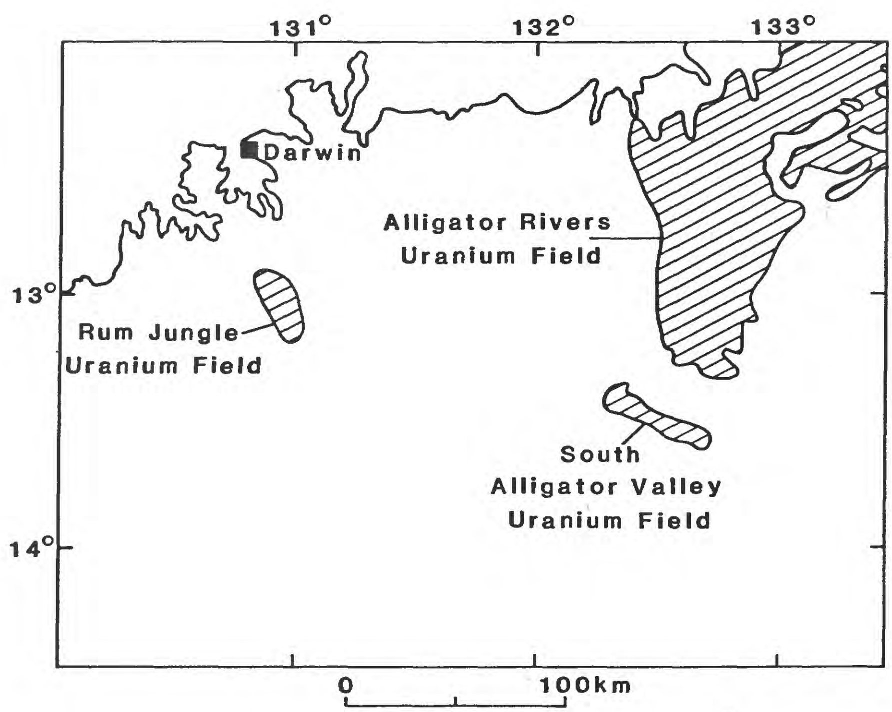


Figure 3.--Uranium fields in the Pine Creek geosyncline.

There are three uranium fields in the Pine Creek geosyncline: Rum Jungle in the west, South Alligator Valley in the southwest, and Alligator Rivers in the east (fig. 3). By far the largest uranium deposits-Jabiluka, Ranger, Koongana and Nabarlek-are unconformity-type and are in the Alligator Rivers Uranium Field (ARUF). Detailed studies of the deposits have been done by Binns and others (1980), (Jabiluka), Gustafson and Curtis (1983), (Jabiluka), Eupene and others (1975), (Ranger), Nash and Frishman (1982), (Ranger), and Ewers and Ferguson (1980), (mineralogy of all deposits).

GEOLOGY OF THE ALLIGATOR RIVERS URANIUM FIELD

Jabiluka, as well as the other deposits in the ARUF, is hosted by metasedimentary rocks of the Lower Proterozoic Cahill Formation, a unit of metapelites, metasandstone, Mg-rich marbles, and carbonaceous schists. The deposits are located in the lower member, which consists of mica schist, carbonaceous schist, feldspathic quartzite, quartzite, amphibolite, calc-silicate gneisses, and marbles. Thick carbonate and calc-silicate layers are present near the base of the member. The lower member of the Cahill Formation grades into the upper member, which is predominantly feldspathic quartz schist, feldspathic schist, feldspathic quartzite, mica schist, and quartzo-feldspathic gneiss, with only minor marble lenses. Compared to the lower member, the upper is more quartz-rich and lacking in thick marbles and carbonaceous schist.

The unconformity-type deposits are close to both the Archean basement and the unconformity separating the Lower Proterozoic metamorphic rocks and the overlying Middle Proterozoic Kombolgie Formation (fig. 4). The Archean rocks are part of the Nanambu Complex, which consists of units that have yielded three isotopic ages: 2500-2400 m.y. massive to foliated granite, 1980-1800 m.y. foliated gneisses that are probably Archean rocks that responded to the 1800 m.y. event, and 1800 m.y. Proterozoic gneisses and schists that accreted to the complex during the 1800 m.y. metamorphism (Page and others, 1980; Needham and Stuart-Smith, 1980)

The Kombolgie Formation unconformably overlies the Cahill Formation. This unit, which forms the Arnham Land Plateau, consists predominantly of quartzose sandstone, with interlayers of intermediate to mafic volcanic rocks, siltstone, and conglomerate. Page and others (1980) dated the Nungbalgarri volcanic member, situated near the middle of the Kombolgie Formation, at 1648 ±29 m.y.

The ARUF uranium deposits are strata-bound, commonly localized in brecciated zones of metasedimentary rocks. Minor uranium ore has also been found in the Kombolgie Formation, near the unconformity (Nash and Frishman, 1982). Graphite schist is within the ore sequence in some deposits, and carbonates are common in the sequence, but outside the ore zones. Extensive chloritization and (or) sericitation is spatially associated with the deposits, occurring with the ore and forming a halo around the ore zones.

JABILUKA GEOLOGY

The unconformity-type deposit at Jabiluka consists of two orebodies in the lower member of the Cahill Formation, near the overlying unconformity. Jabiluka 1, the first discovery, is an erosional window in the Kombolgie

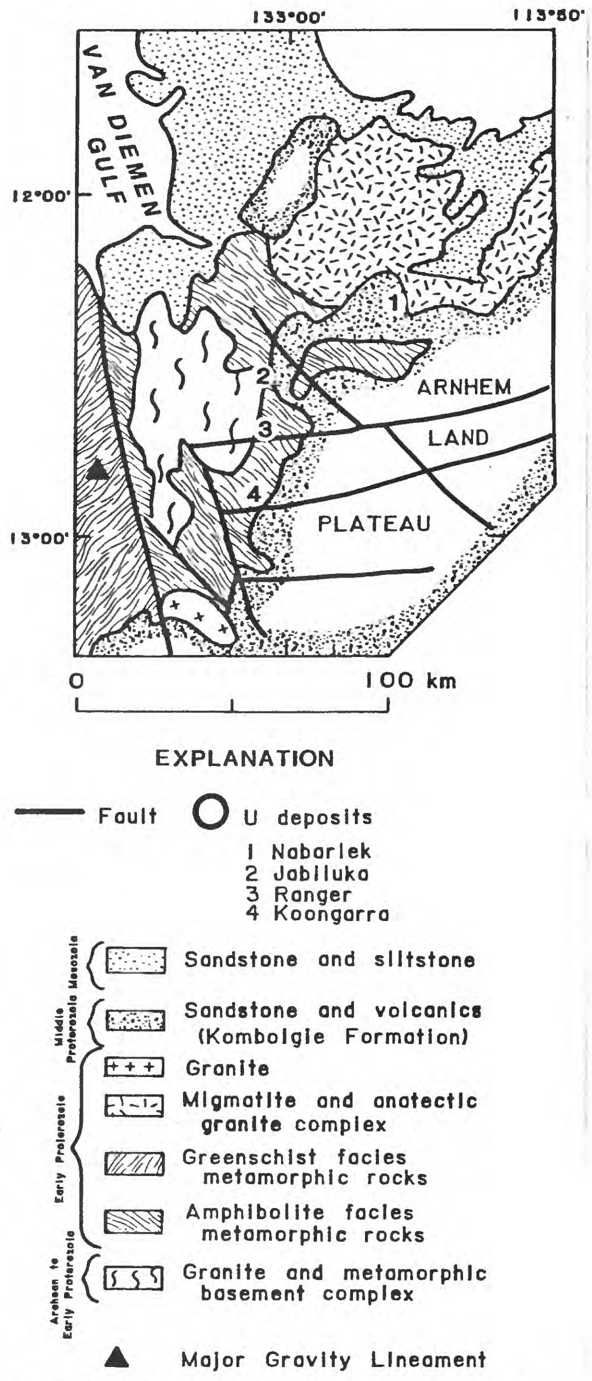


Figure 4.--Simplified geology of the East Alligator River Uranium Field and surrounding region for the Australian Bureau of Mineral Resources, Geology and Geophysics, 1980.

Formation. Jabiluka 2 is overlain by 20-220 meters of sandstone (Hegge and others, 1980). Two sills of Zamu Dolerite underlie Jabiluka 1 (Needham and Stuart-Smith, 1980).

The deposits are in a sequence of highly chloritized schists and breccias. The main rock types in the deposit are as follows (all include quartz): chlorite-muscovite schist, chlorite-sericite schist, chlorite-muscovite-sericite schist, chlorite-sericite-muscovite schist, chlorite schist, and chlorite-graphite schist. Dolomitic marbles, garnetite, and amphibolite are present in the deposit area, but not in the ore zones. Uranium mineralization is commonly in sequences of chlorite schist, graphite schist, and chlorite-sericite schist. Barren zones tend to be composed of the muscovite-rich rocks. Uranium minerals are filling open spaces in breccias and in veins and are disseminated in schist.

The Pancontinental geologists have defined the stratigraphy at Jabiluka as being composed of 9 units (fig. 5). Most of the details of the stratigraphy are based on megascopic observation of the core. Despite the extensive chloritization of the rocks in and around ore zones and the attendant difficulty in identifing individual mineral phases, the stratigraphy and the criteria for picking stratigraphic breaks hold up in both Jabiluka 1 and 2. Microscope, microprobe, and X-ray studies will refine the descriptions and will determine the differences between muscovite and sericite and among chlorites.

DESCRIPTION OF ROCK UNITS

The upper schist series (fig. 5), which is usually thin or absent, is a barren unit overlying the ore zone. Chlorite-muscovite schist and chlorite-muscovite-sericite schist are the most common rock types sampled in this section.

The upper graphite series is predominantly chlorite-graphite schist and chlorite-sericite-muscovite schist. The contact between the upper schist series and the upper graphite series is marked by the first appearance of graphite schist. Some uranium ore occurs in this unit, but much less than in the more brecciated graphite layers lower in the sequence.

The hanging wall schist series underlying the upper graphite series is first identified by the appearance of muscovite-rich schist and the absence of graphite. The main rock types of this series are chlorite-muscovite schist, muscovite-chlorite schist, chlorite-muscovite-sericite schist, chlorite-sericite-muscovite schist, and chlorite-sericite schist. Two graphite layers are usually present in the upper half of the unit. Pseudomorphs of chlorite after garnet are common, especially in the chlorite-muscovite schist.

The main mine series, which underlies the hanging wall schist series, is the major ore-bearing unit. This series is predominantly chlorite schist, commonly with appreciable graphite, and chlorite-sericite schist. The top of the main mine series is marked by a graphite layer and by the absence of muscovite-rich rocks. Brecciation of the main mine series is extensive, and the brecciated zones are one of the primary hosts of uranium ore. Pancontinental's geologists correlate the main mine series with a marble sequence outside the ore zone.

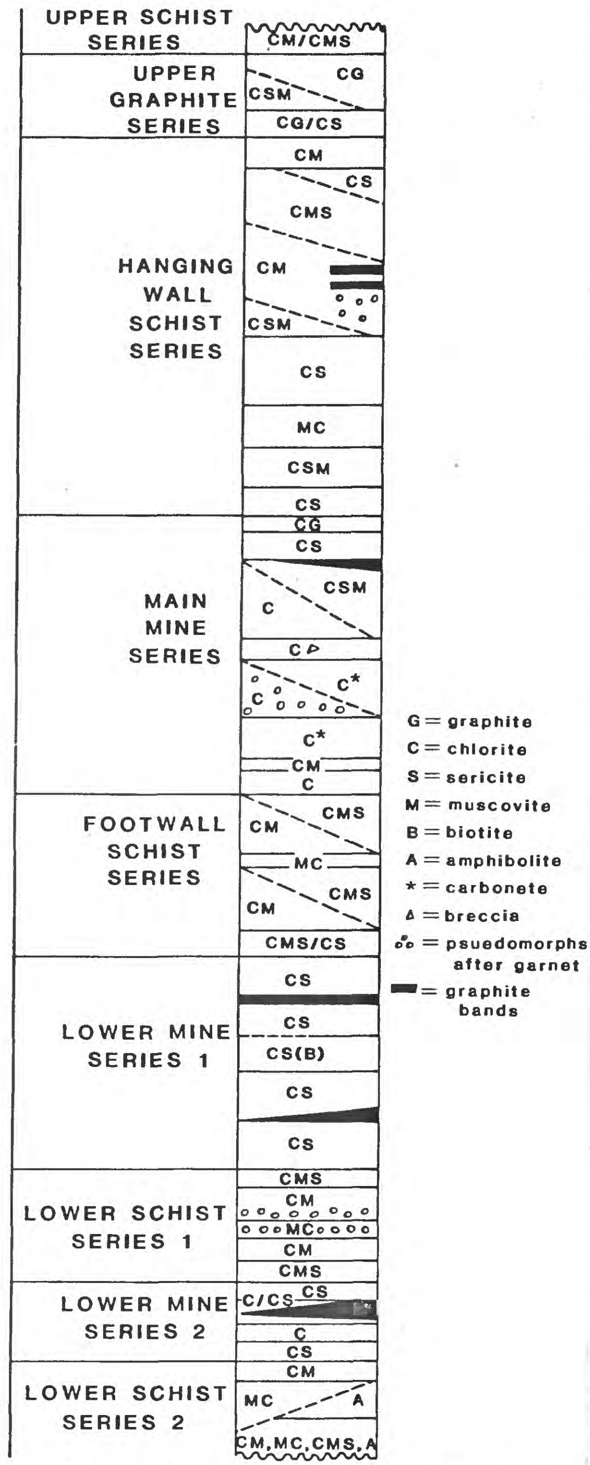


Figure 5.--Stratigraphic section of the Cahill Formation in the Jabiluka orebodies. Modified from information supplied by Pancontinental Mining Limited.

The footwall schist series is a muscovite-rich sequence consisting of chlorite-muscovite schist, chlorite-muscovite-sericite schist, and minor chlorite-sericite schist. Footwall and hanging wall lithologies are essentially the same and are only distinguishable by their position in the sequence. The upper contact of the footwall schist series is picked at the appearance of muscovite-rich strata, which coincides with the end of the chlorite-sericite sequence.

The lower mine series 1 is an ore-bearing unit of chlorite-sericite schist with sparse graphite bands. The upper contact is marked by the gradual loss of muscovite and the first appearance of a graphite band.

A barren unit, the lower schist series 1, underlies the lower mine series 1. This is a muscovite-rich unit consisting of chlorite-muscovite schist, chlorite-muscovite-sericite schist, and muscovite-chlorite schist. Pseudomorphs of chlorite after garnet are common. The upper contact is defined by the gradational increase in muscovite and graditional loss of sericite.

The lower mine series 2 is the lowest ore zone. Like the other ore zones it consists predominantly of chlorite schist and chlorite-sericite schist, with some graphite bands. The gradational upper contact is marked by the appearance of sericite, the loss of muscovite, and the presence of graphite bands in the upper part of the unit.

The lower schist series 2 underlies the ore zone. This sequence consists of chlorite-muscovite schist, muscovite-chlorite schist, amphibolite, and minor chlorite-muscovite-sericite schist.

The entire Jabiluka sequence is cut by quartz veins and pegmatite. Emplacement of the quartz veins was episodic, occuring before, during, and after mineralization. Chlorite veins are in the chloritized zone and some are spatially associated with uranium mineralization. Late carbonate veins cut across the entire sequence. Swarms of chloritized tourmaline-bearing pegmatites intrude the Cahill Formation, producing zones of mixed, hybrid pegmatoid rock.

Figures 6a through 6s are Pancontinental Mining Limited preliminary cross-sections through Jabiluka 1 and 2, showing the sequence, structure and, in some cases, ore. The drill holes sampled are shown on the appropriate cross-sections. The cross sections are shown as they were supplied by Pancontinental Mining Limited.

Figure 6a through s.--Preliminary vertical cross sections through Jabiluka and 2 showing drill hole locations; these are the cross sections that include drill-hole core sampled by the U.S. Geological Survey. Cross section lines are on Figure 1. Geology is shown as supplied by Pancontinental Mining Limited.

EXPLANATION

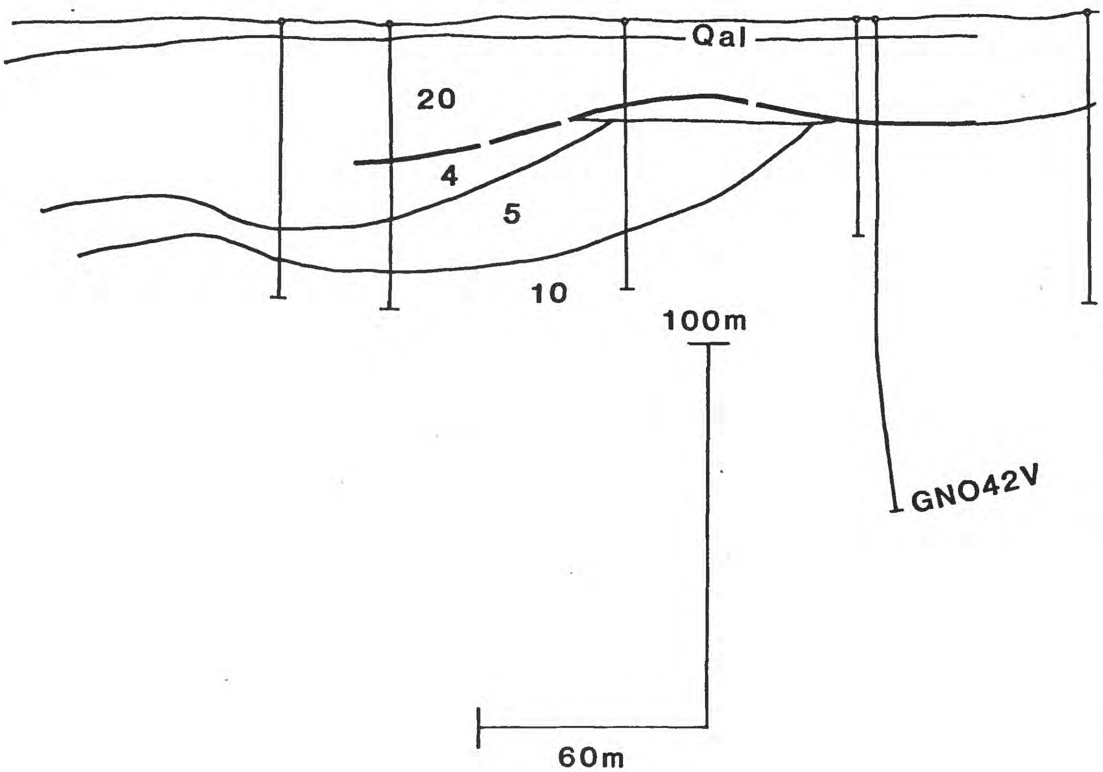
Quaternary		Qal	Sand, soil
Middle Proterozoic	Kombolgie Formation	20	
		1	Upper Schist Series
		2	Upper Graphite Series
		3	Hanging Wall Schist Series
Lower Proterozoic	Cahill Formation	4	Main Mine Series
		5	Footwall Schist Series
		6	Lower Mine Series 1
		7	Lower Schist Series 1
		8	Lower Mine Series 2
		9	Lower Schist Series 2
		10	Undifferentiated schist
	Intrusive pegmatite	P	Tourmaline pegmatite

——— Contact

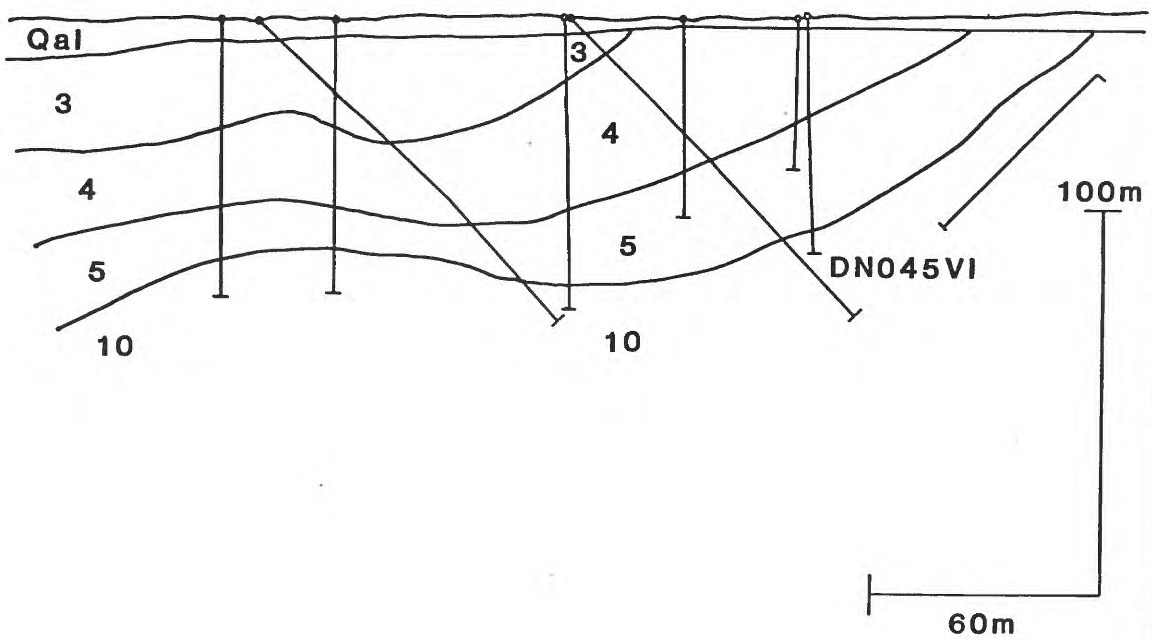
——— Fault

● Ore zone

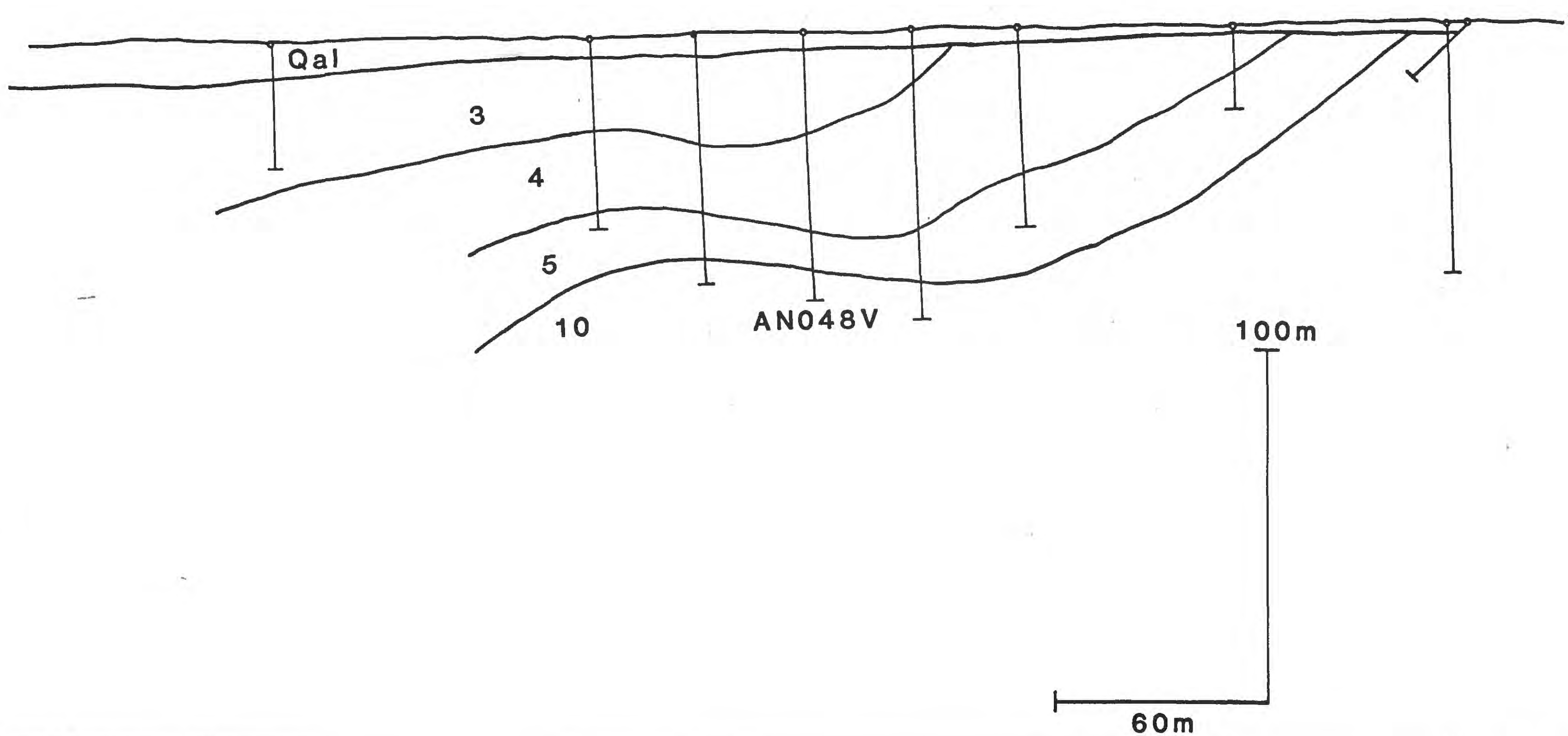
The contact between the Kombolgie Formation and the Cahill Formation is an unconformity along which faulting has occurred. On the cross sections, the Pancontinental geologists do not distinguish the type of contact; instead, the cross sections show a formational contact between the Kombolgie and the Cahill Formations.



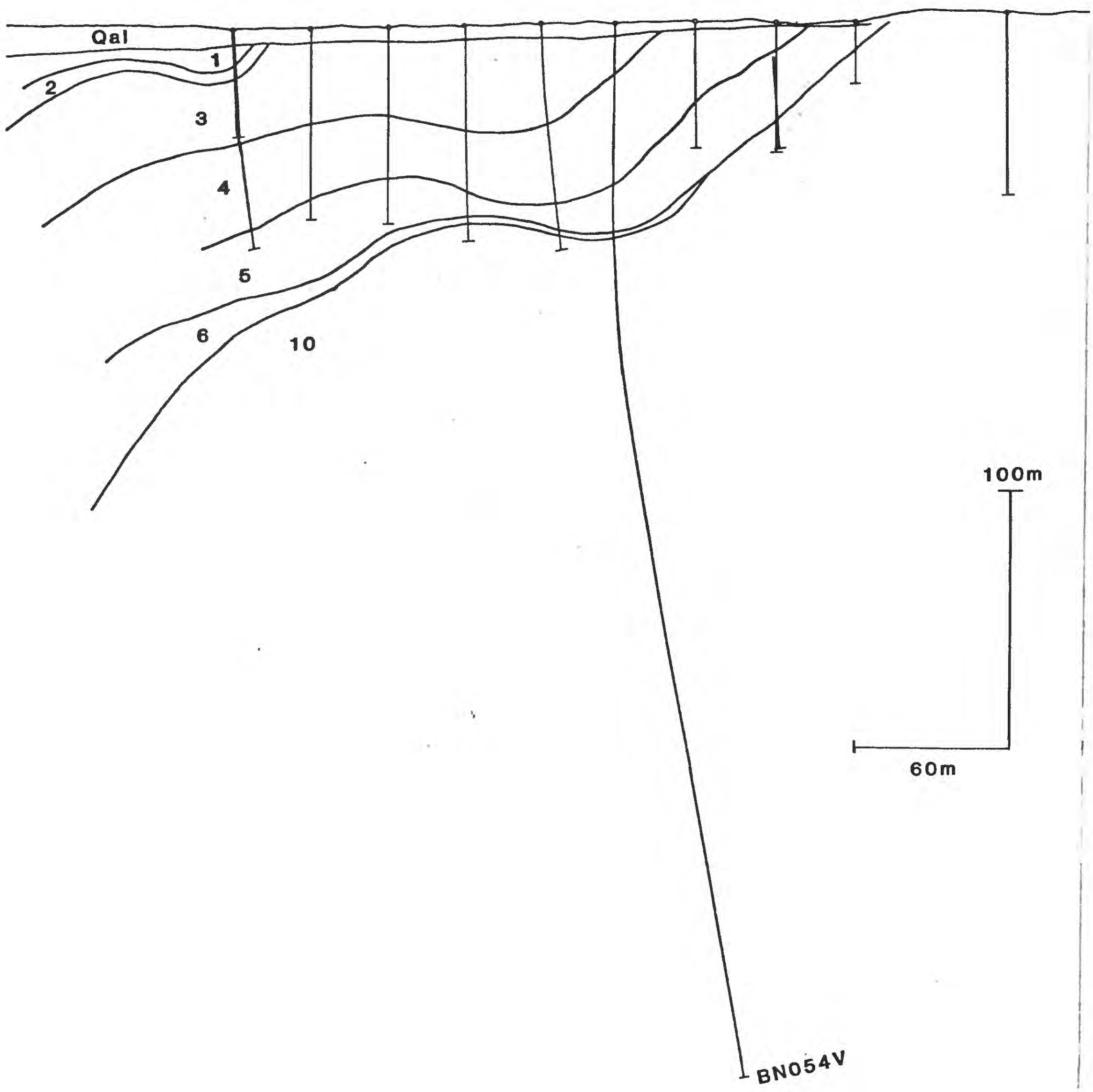
a.--042 cross section.



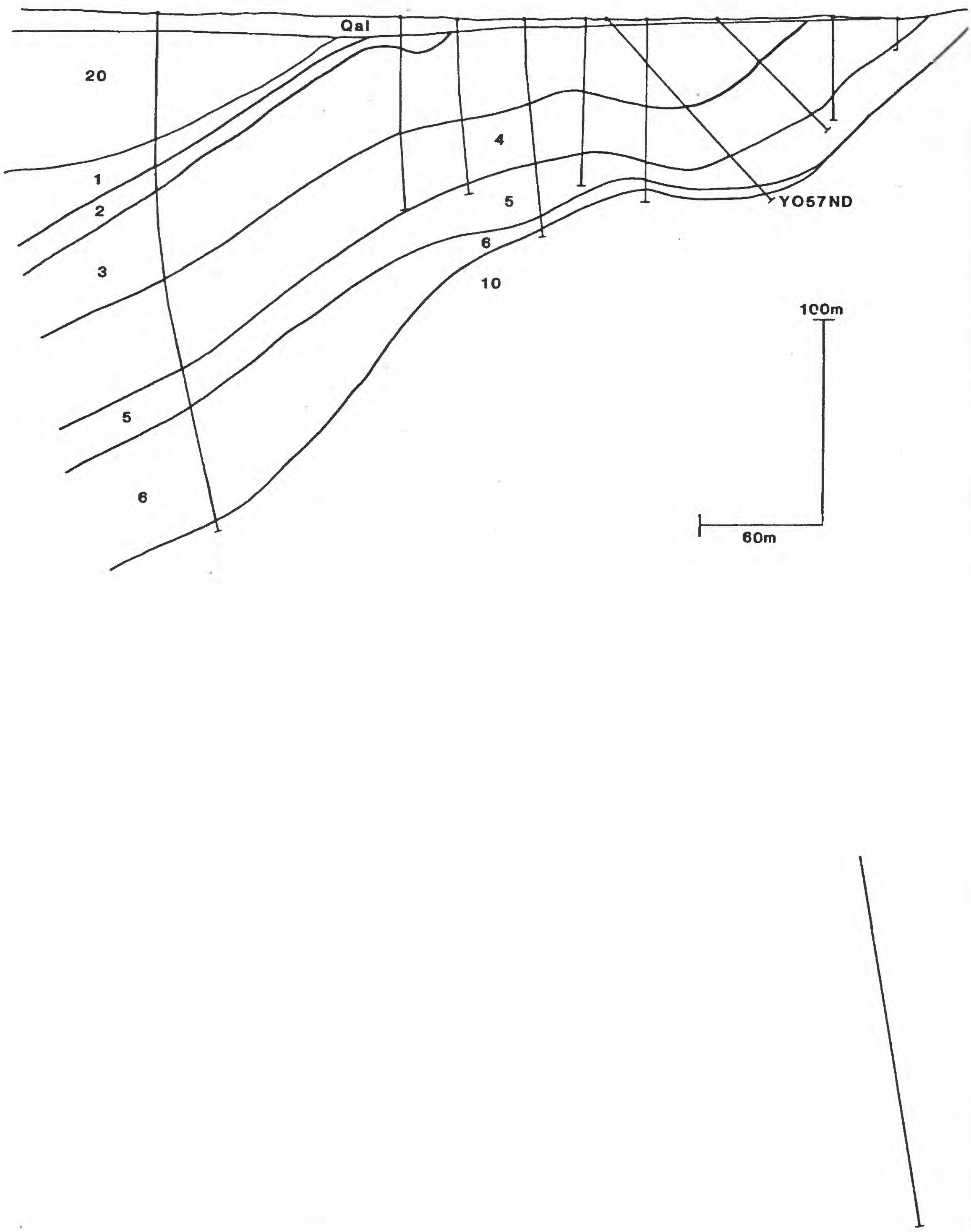
b.--045 cross section.



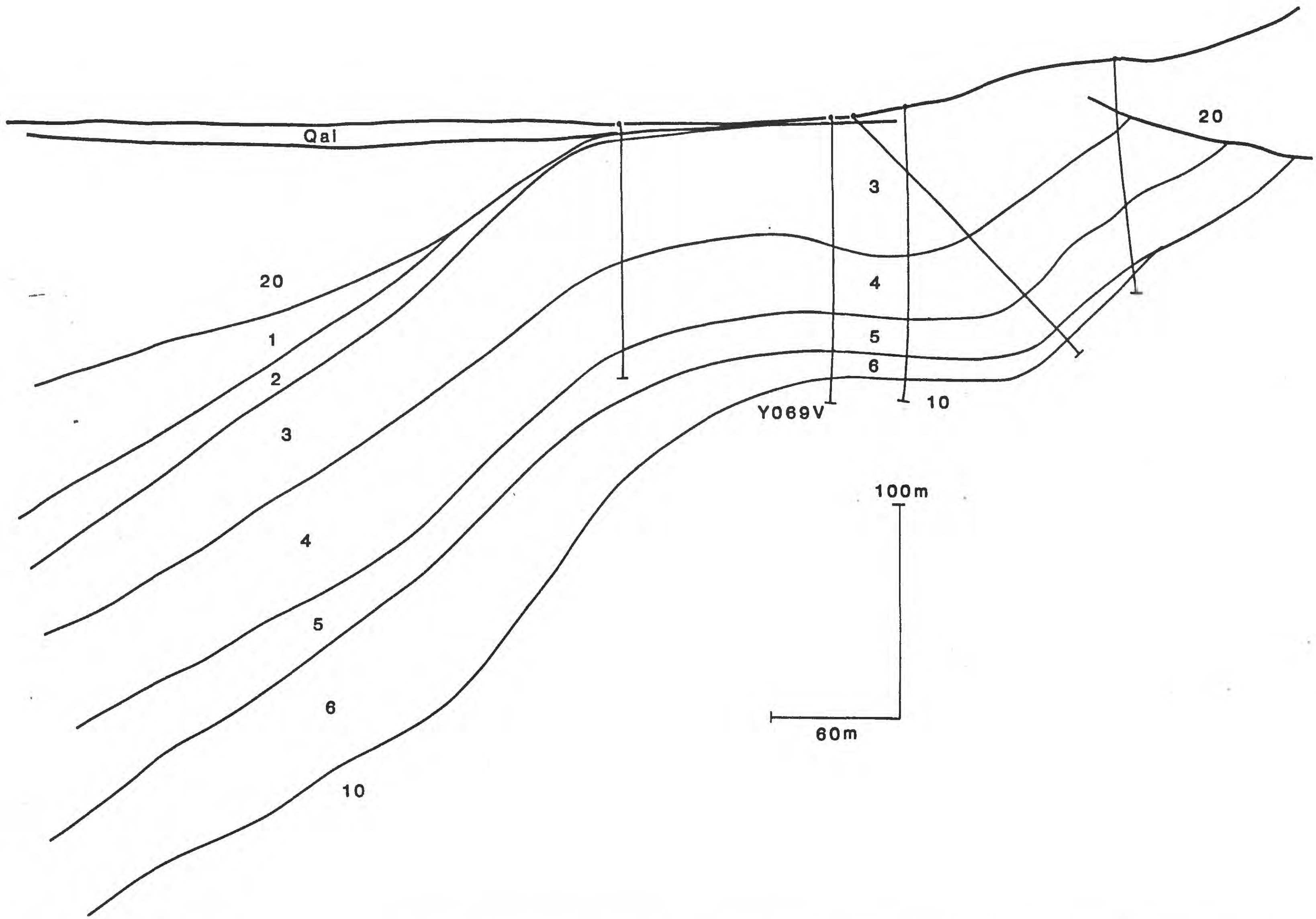
c.--048 cross section.



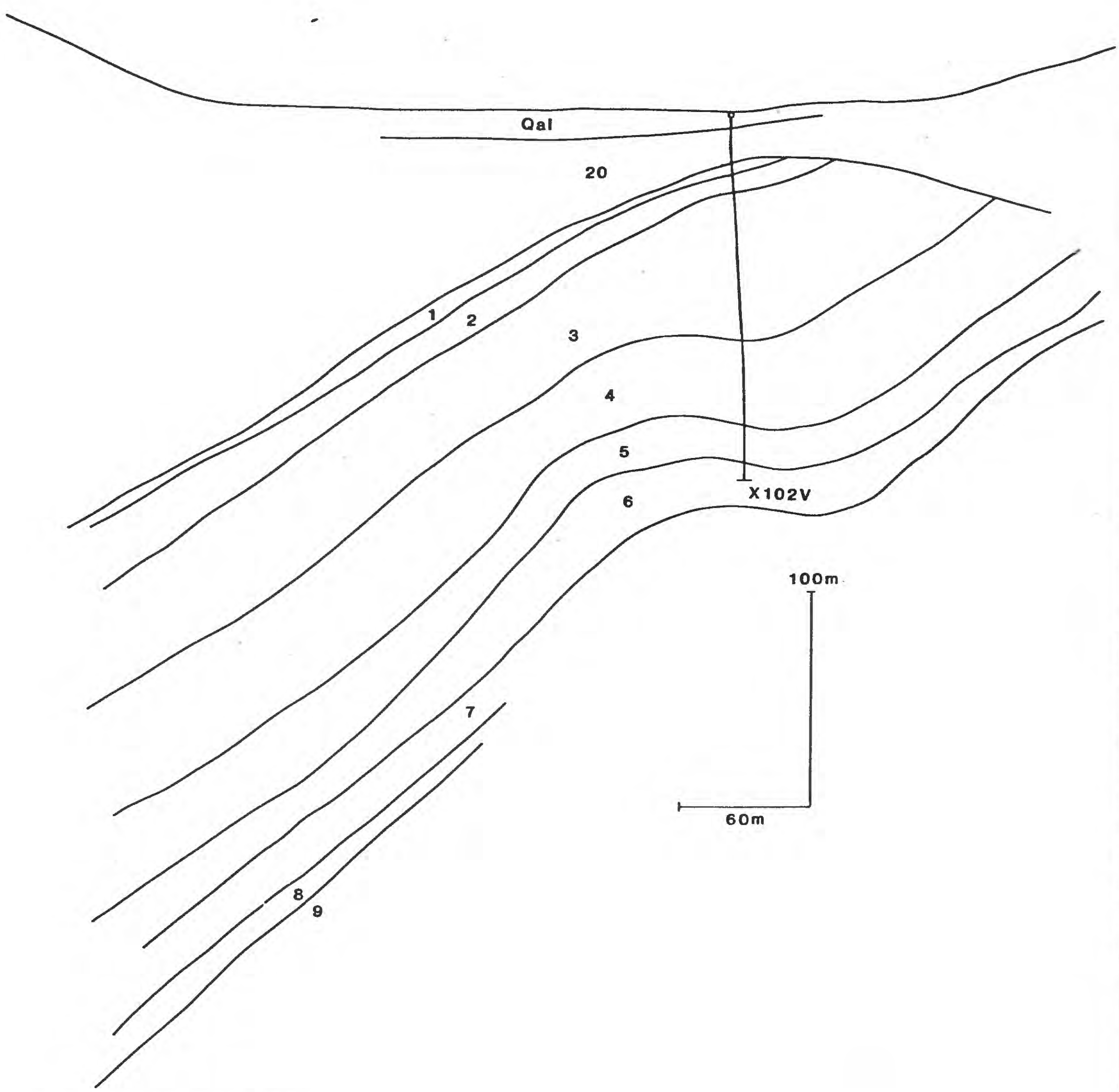
d.--054 cross section.



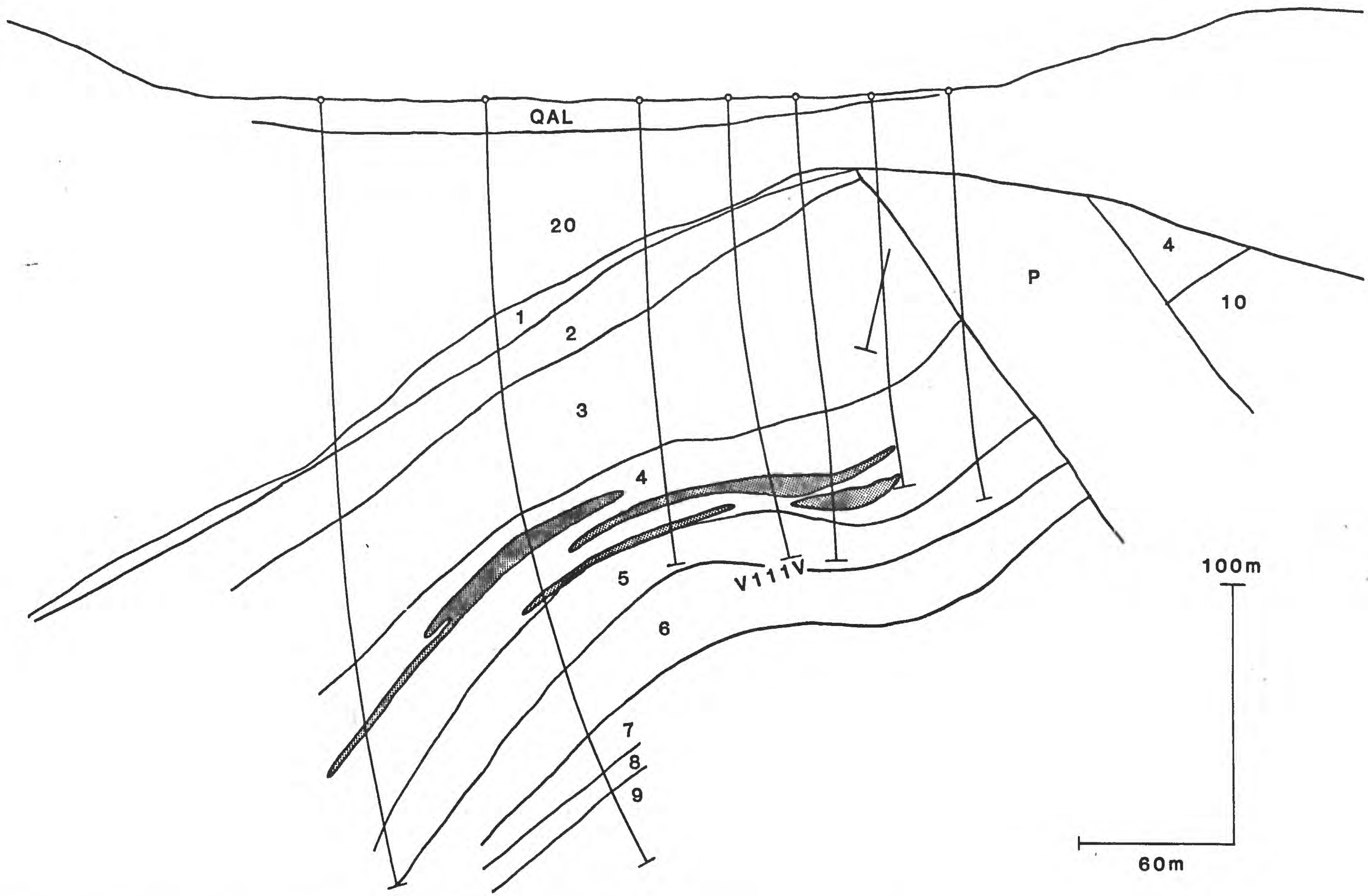
e.--057 cross section.



f.--069 cross section.

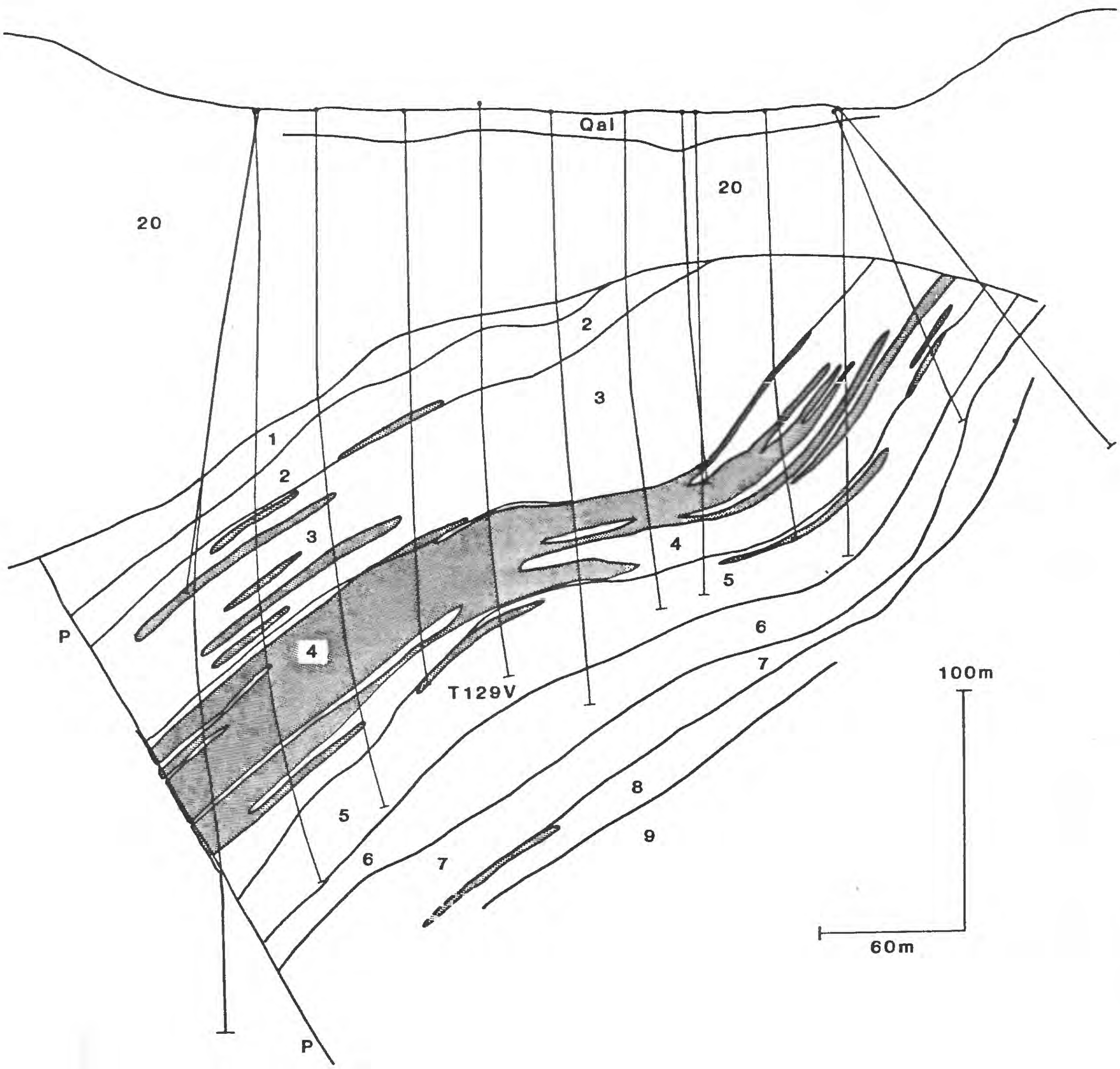


g.--102 cross section.

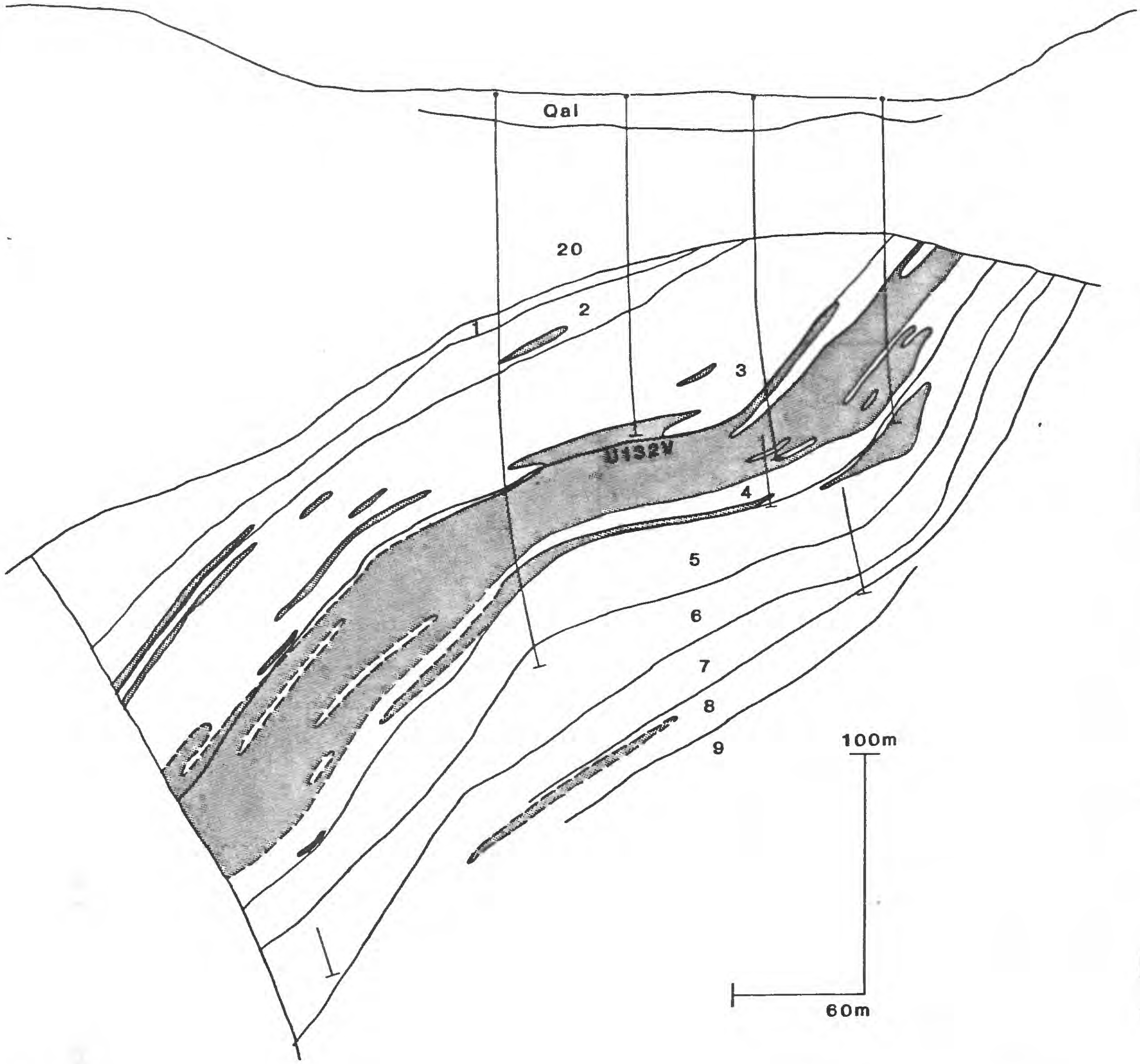


h.--111 cross section.

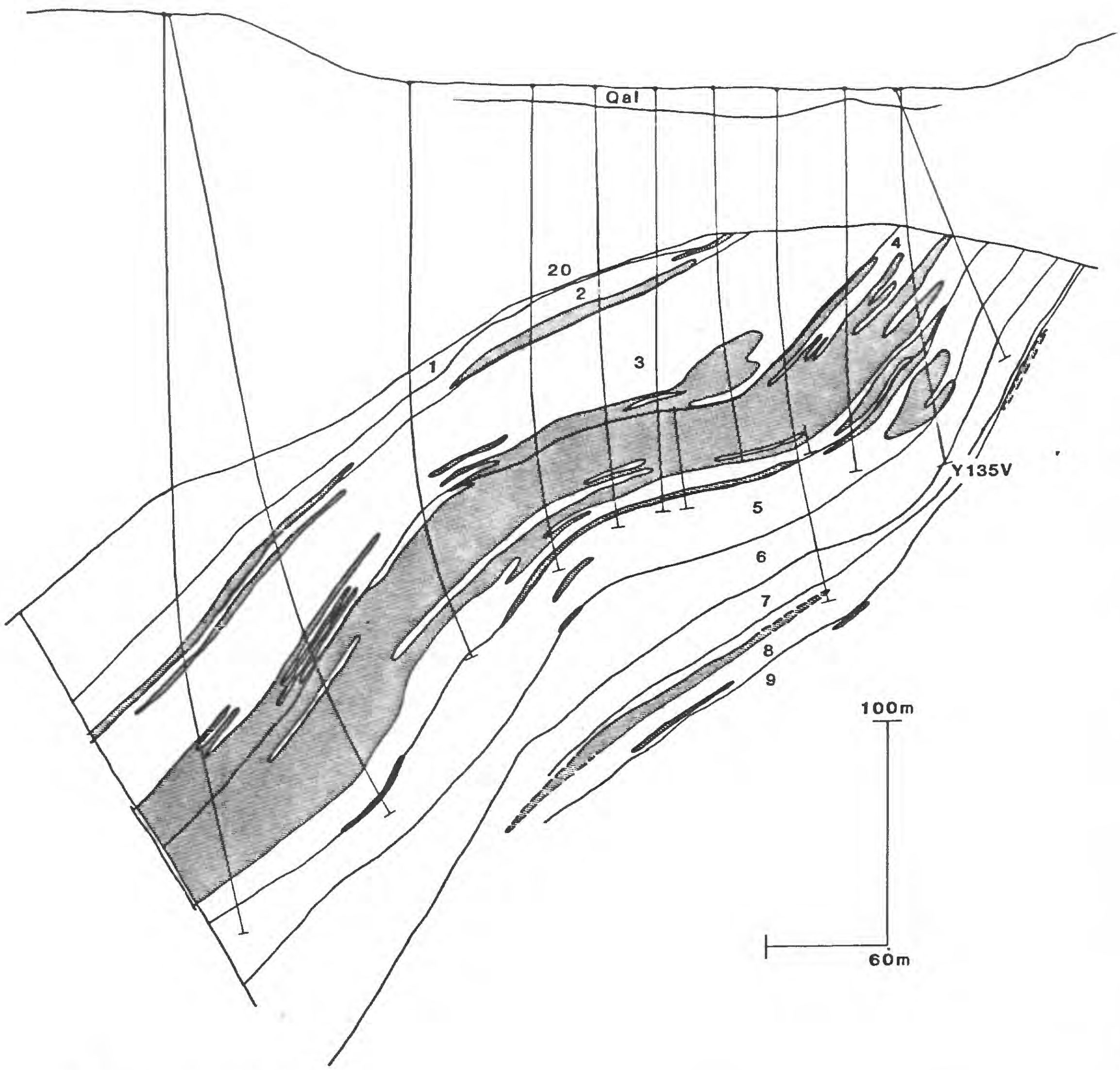
i.--123 cross section.



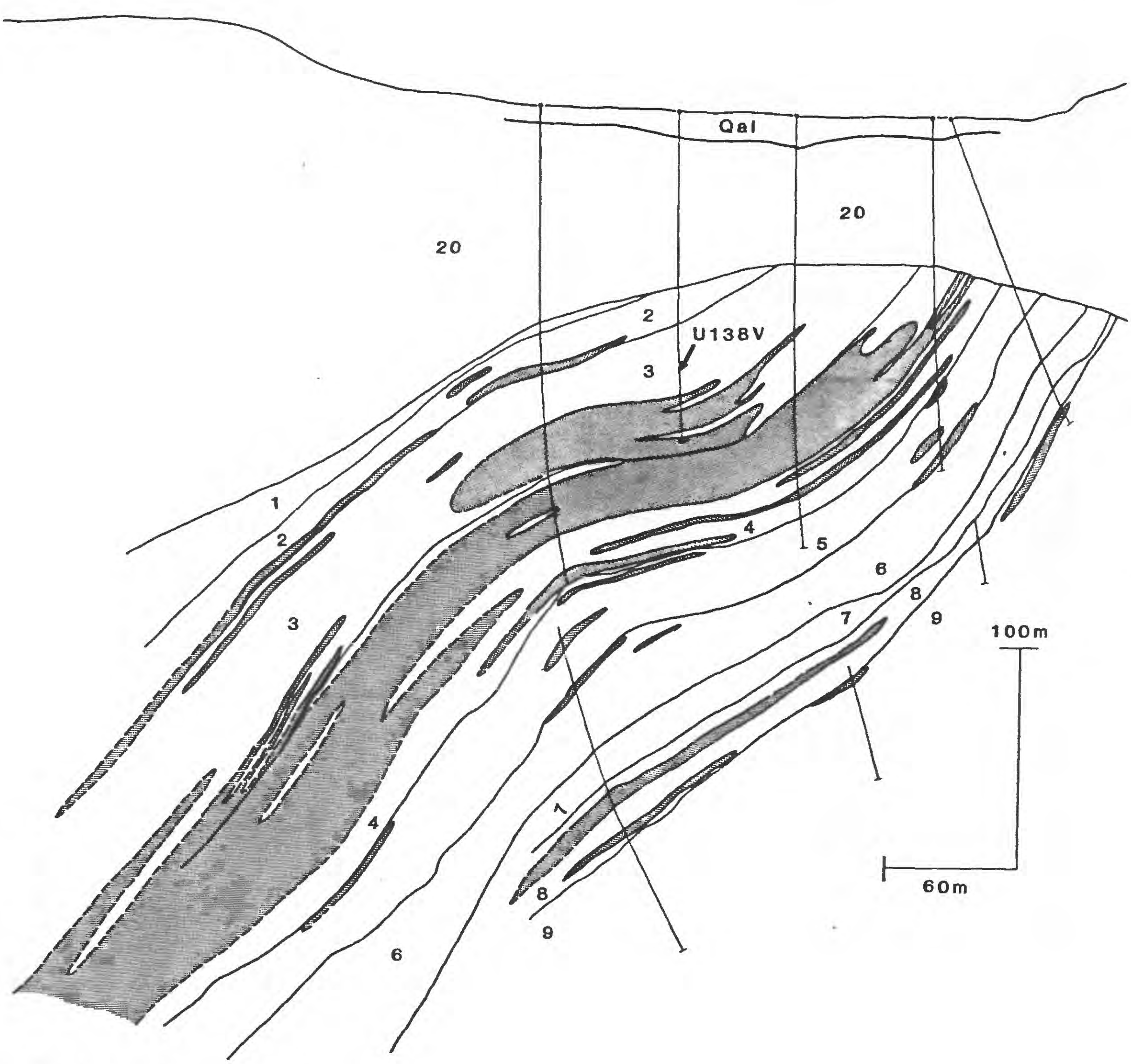
j.--129 cross section.



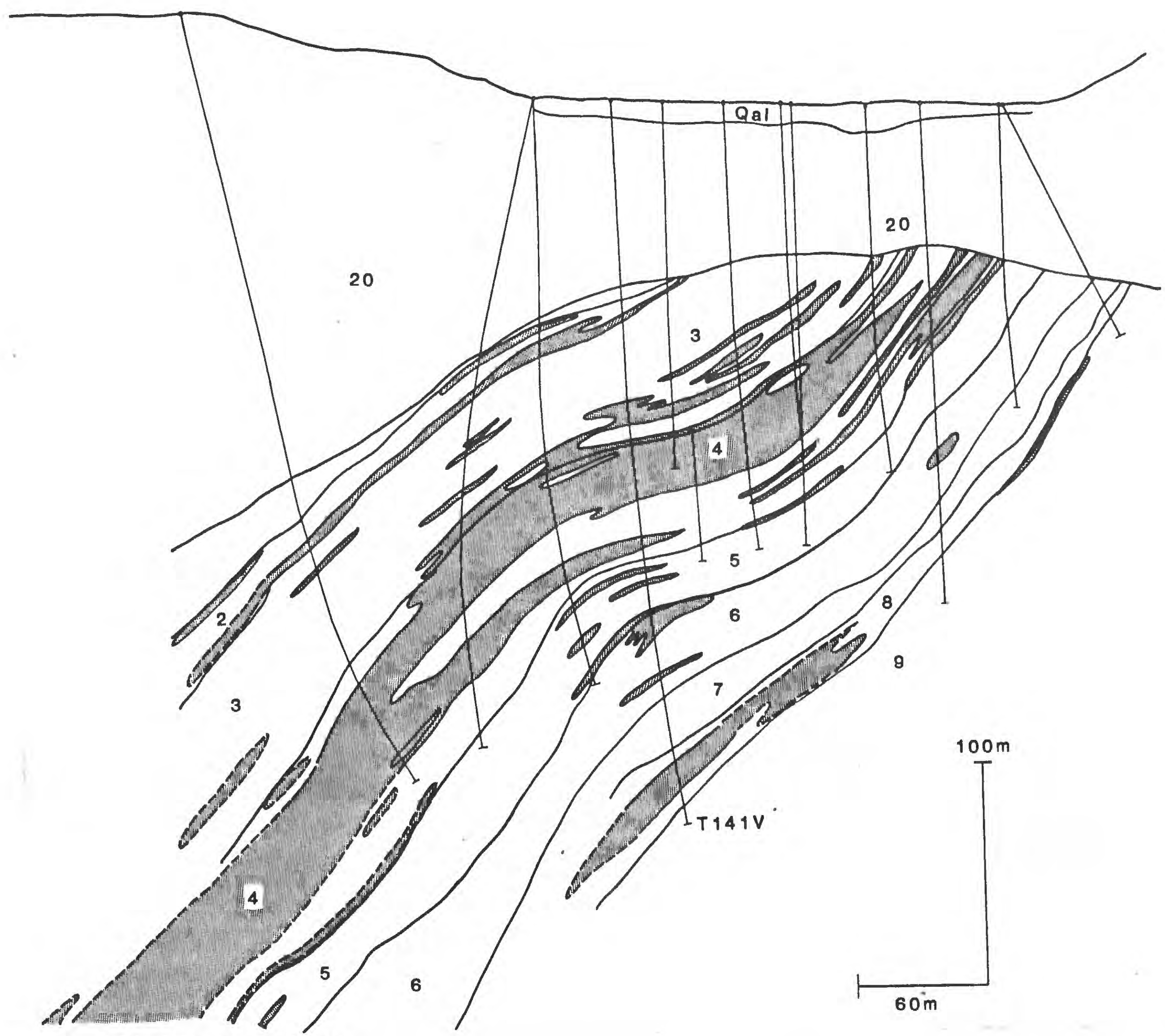
k.--132 cross section.



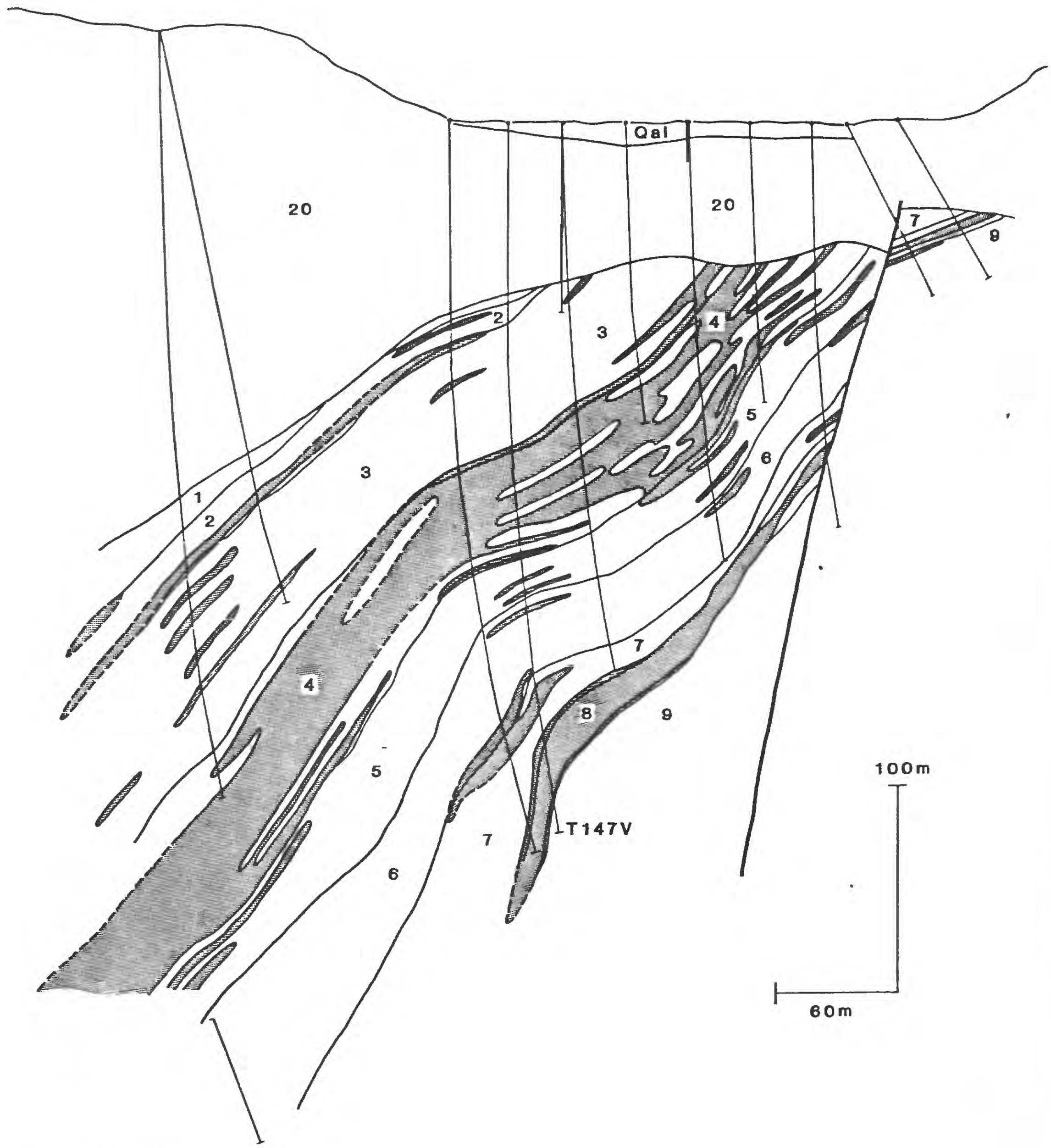
1.--135 cross section.



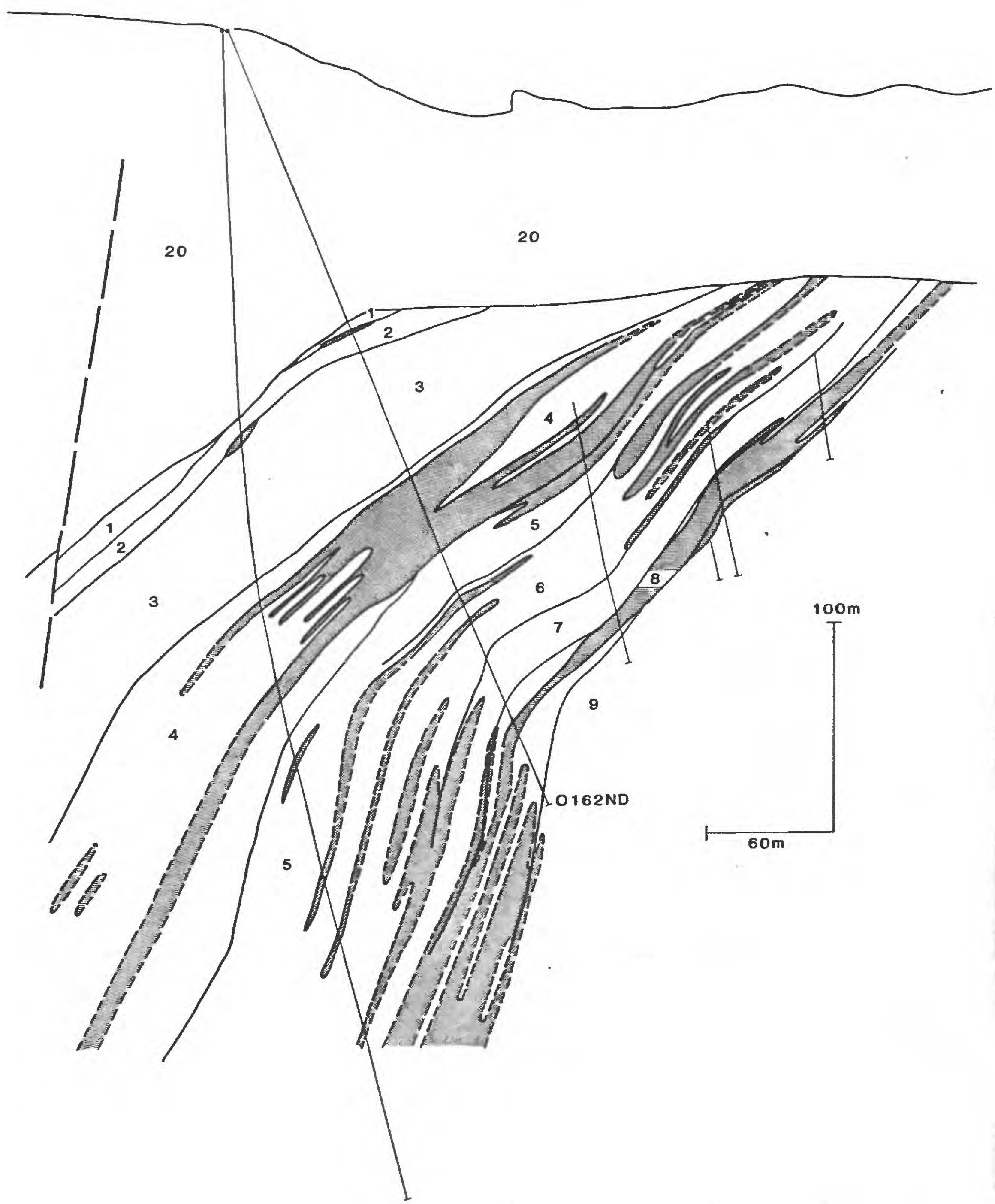
m.--138 cross section.



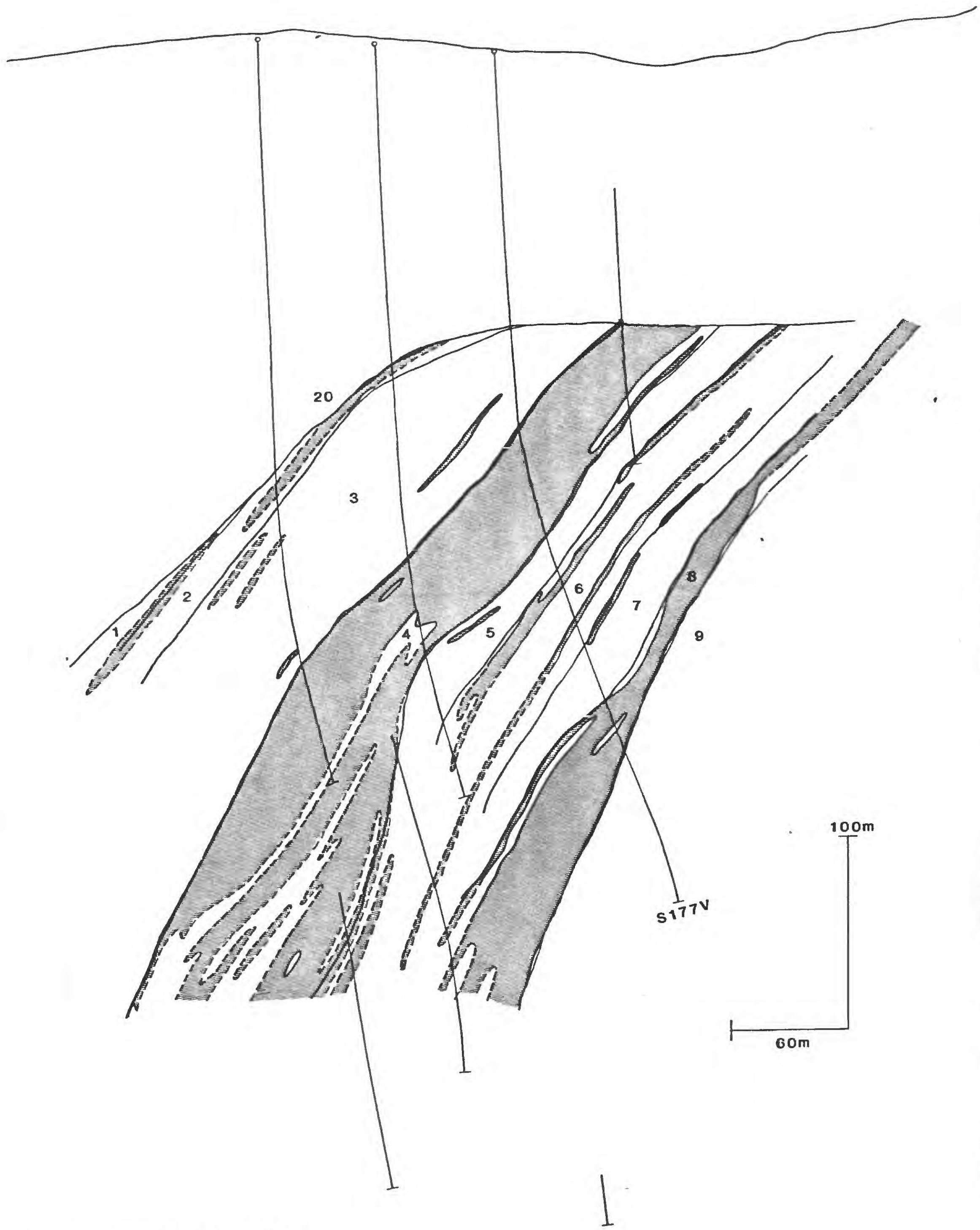
n.--141 cross section.



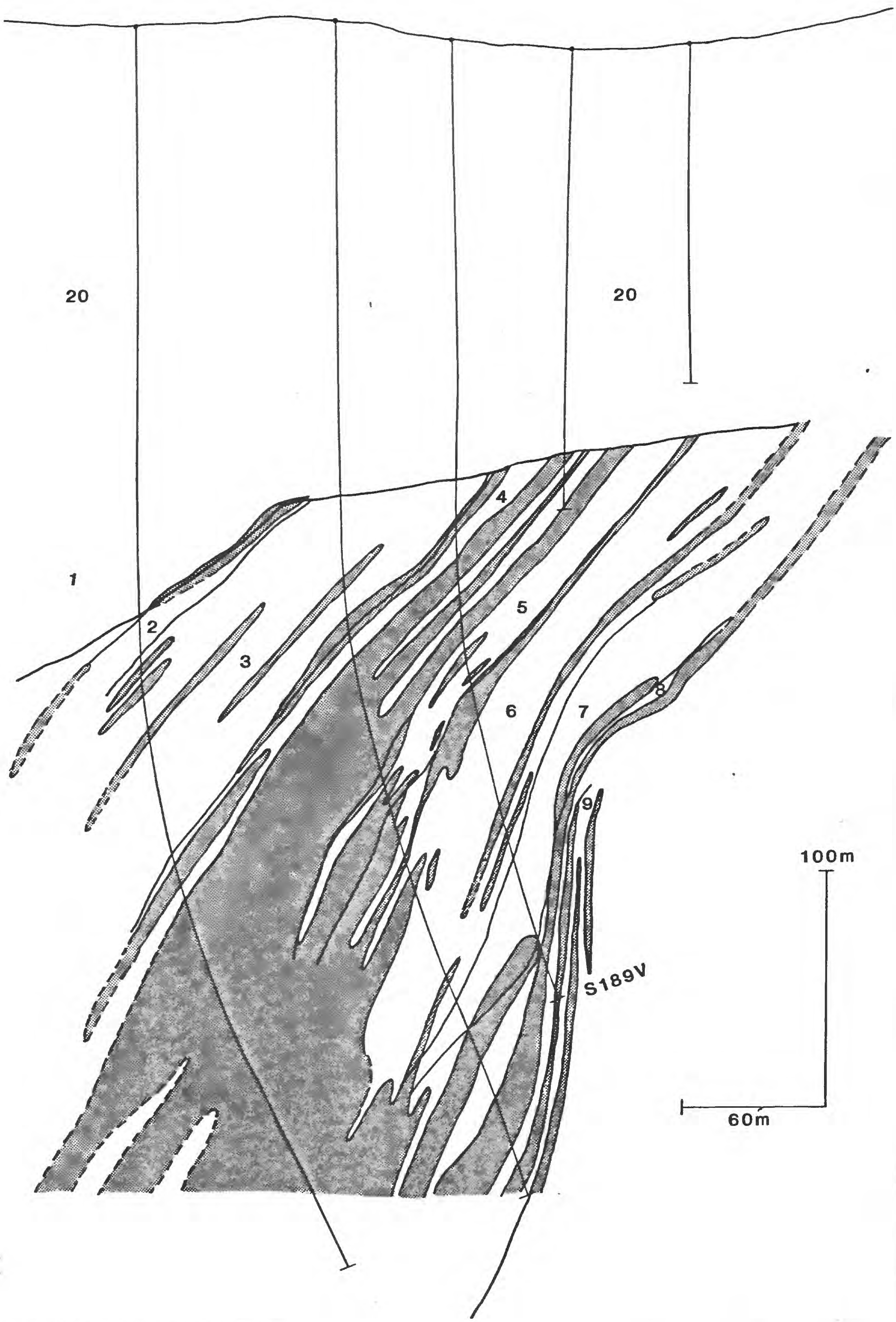
o.--147 cross section.



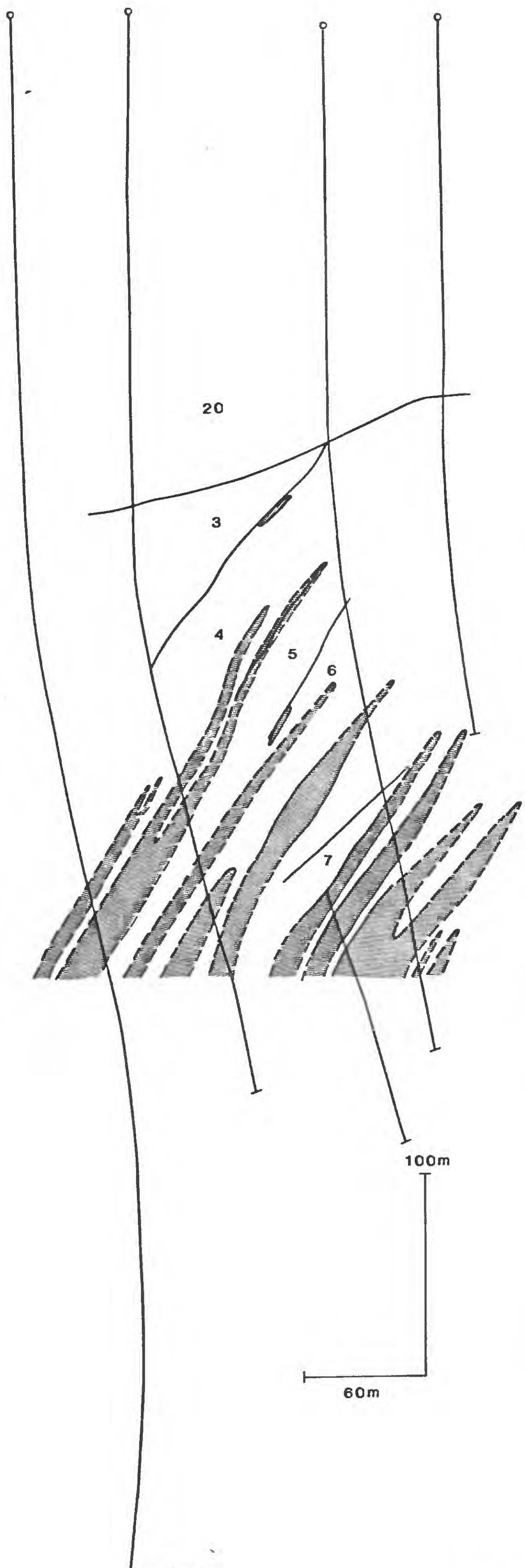
p.--162 cross section.



q.--177 cross section.



r.--189 cross section.



s.--204 cross section.

REFERENCES

Binns, R.A., Ayres, J.R., Wilmhurst and Ramsden, 1980, Petrology and geochemistry of alteration associated with uranium mineralization, in Ferguson, John, and Goleby, A.B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 417-438.

Binns, R. A., McAndrew John, and Sun, S-S, 1980, Origin of Uranium mineralization at Jabiluka, in Ferguson, John, and Goleby, A.B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 543-562.

Bureau of Mineral Resources, Geology and Geophysics, 1980, Solid geology of the Pine Creek Geosyncline, Northern Territory, 1979, in Ferguson, John, and Goleby, A.B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency.

Eupene, G. S., Fee, P. H., and Colville, R. G., 1975, Ranger One uranium dsposits, in Knight, C. L., ed., Economic geology of Australia and Papua, New Guinea. 1. Metals: Parkville, Australian Inst. Min. Metal. Mon. 5, p. 308-317

Ewers, G. R., and Ferguson, John, 1980, Mineralogy of the Jabiluka, Ranger, Koongarra and Nabarlek uranium deposits, in Ferguson, John, and Goleby, A. B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 363-374.

Gustafson, L. B., and Curtis, L. W., 1983, Post-Kombolgie metasomatism at Jabiluka, Northern Territory, Australia, and its significance in the formation of high-grade uranium mineralization in Lower Proterozoic rocks: Econ. Geology, v. 78, p. 26-56.

Hegge, M.R., Mosher, D.V., Eupene, G.S., and Anthony, P.J., 1980, Geologic setting of the East Alligator uranium deposits and prospects, in Ferguson, John, and Goleby, A.B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 259-272.

Hegge, M.R., and Rowntree, J.C., 1978, Geologic setting and concepts on the origin of uranium deposits in the East Alligator River region, Northern Territory, Australia: Econ. Geology, v.73, p. 1420-1429.

Nash, J. T., and Frishman, David, 1982, Progress report on geologic studies of the Ranger ore bodies, Northern Territory, Australia: U.S. Geol. Survey Open-File Report 82-936, 49 p.

Needham, R.S., Crick, I.H., and Stuart-Smith, 1980, Regional geology of the Pine Creek Geosyncline, in Ferguson, John, and Goleby, A.B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 1-22.

Needham, R.S., and Stuart-Smith, P.G., 1980, Geology of the Alligator Rivers Uranium Field, in Ferguson, John, and Goleby, A. B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 233-257.

Page, R. W., Compston, William, and Needham, R. S., 1980, Geochronology and evolution of the late-Archean basement and Proterzoic rocks in the Alligator Rivers Uranium Field, Northern Territory, Australia, in Ferguson, John, and Goleby, A. B., eds., Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline: Vienna, International Atomic Energy Agency, p. 39-68.

Rowntree, J. C., and Mosher, D. V., 1976, Case history of the discovery of the Jabiluka uranium deposits, East Alligator River region, Northern Territory of Australia, in Exploration for uranium ore deposits: Vienna, International Atomic Energy Agency, p. 551-573.