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TRIASSIC FOSSIL FISH FROM THE SULPHUR MOUNTAIN FORMATION, KAKWA RECREATION AREA, NORTHEASTERN BRITISH COLUMBIA (93I/1)

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INTRODUCTION

Fossil fish have been known from the Triassic Sulphur Mountain Formation in western Canada since the beginning of this century, with the first specimens found at a locality near Banff, Alberta (Lambe, 1914, 1916). In 1947, fish fossils were discovered near Wapiti Lake, in northeastern British Columbia (Figure 1-7-1), by a group of researchers from the University of Wisconsin (Laudon *et al.*, 1949). Since that time, a number of expeditions have visited the Wapiti Lake area, which has proved to be a prolific collecting locality. More than one thousand specimens, many of which are articulated, representing 16 genera have been recovered and three distinct faunas recognized. Commercial collecting occurred in the area in the past; however, it is now considered a Provincial Heritage Site and is protected. Six sites from which fossiliferous material was collected *in situ* have been identified within a belt 2.5 kilometres long, south of Wapiti Lake; however, a single site in this area has produced most of the specimens (Brinkman and Neuman, 1987; Neuman, in press; Schaeffer and Mangus, 1976). Ichthyosaur reptiles were also found at four of the six sites (Callaway and Brinkman, 1989).

A second Triassic fossil fish locality in British Columbia, located approximately 50 kilometres south-southeast of Wapiti Lake, was encountered in Kakwa Recreation Area during the course of a mineral potential study, conducted in the summer of 1991 (Pell *et al.*, 1992, this volume). It was originally found by Dr. Barry Richards of the Geological Survey of Canada in the early 1980s (A. Neuman and B. Richards, personal communication, 1991), but has not previously been reported on. The area is remote and access is most easily attained by helicopter. Because of its location within a Provincial Recreation Area, the site is protected and open only to scientific study by application to the British Columbia Ministry of Environment, Lands and Parks.

A number of articulated specimens and numerous fossil fragments were collected during brief visits to the site. All samples were found on a scree slope beneath outcrops of the Sulphur Mountain Formation or in loose blocks scattered amongst the outcrop. In this vicinity, the Sulphur Mountain Formation is exposed in steep to cliffy outcrops that are flaggy weathering and unstable. Little time was spent on the outcrops themselves, due to their hazardous nature and, as a result, no fossils were found *in situ*.

GEOLOGICAL SETTING

The Sulphur Mountain Formation is exposed in a northwest-trending belt (Figure 1-7-1) that extends from north of Wapiti Lake, through Kakwa Recreation Area into Alberta, to the southeast of Kakwa (McMechan, 1986; McMechan and Thompson, 1985; Taylor and Stott, 1979). It is a moderately resistant, characteristically dark reddish brown to brownish orange weathering unit that unconformably overlies black, lichen-covered sandstones of the Permian Mowich Formation and is conformably overlain by buff and grey carbonate rocks of the Late Triassic Whitehorse Formation. The Sulphur Mountain Formation has been subdivided into the Vega-Phroso, Whistler and Llama members, in ascending order (Table 1-7-1).

In the Kakwa area, the Vega-Phroso siltstone member is 245 to 270 metres thick and comprises a shaley to flaggy weathering sequence of dolomitic and calcareous siltstone, fine-grained sandstone, silty limestone and shale that ranges in age from Early Triassic Griesbachian to Spathian (Gibson, 1975). It is platey near the base and becomes increasingly flaggy up-section. Ammonites are locally common within this member. However, they are generally poorly preserved, occurring as faint imprints on bedding planes. Well-preserved ammonites were rare finds (Plate 1-7-1). Chondrichthyian spines (*cf. Listracanthus* sp.) are common in some strata (Plate 1-7-2) and are believed to represent some part of the skin of ancient sharks (A. Neu-

TABLE 1-7-1
PERMIAN AND TRIASSIC STRATIGRAPHY

	Formation	Member	Stage	Series
SPRAY RIVER GROUP	Whitehorse Formation	Starlight Evaporite	Carnian	Late Triassic
	Sulphur Mountain Formation	Llama	Ladinian	Middle Triassic
		Whistler	Anisian	
		Vega-Phroso Siltstone	Spatian	Early Triassic
			Smithian	
			*Din/Grsb	
	Mowich	unconformity		Permian

*DIN/Grsb = Dienerian & Griesbachian
Table modified from Gibson, 1975

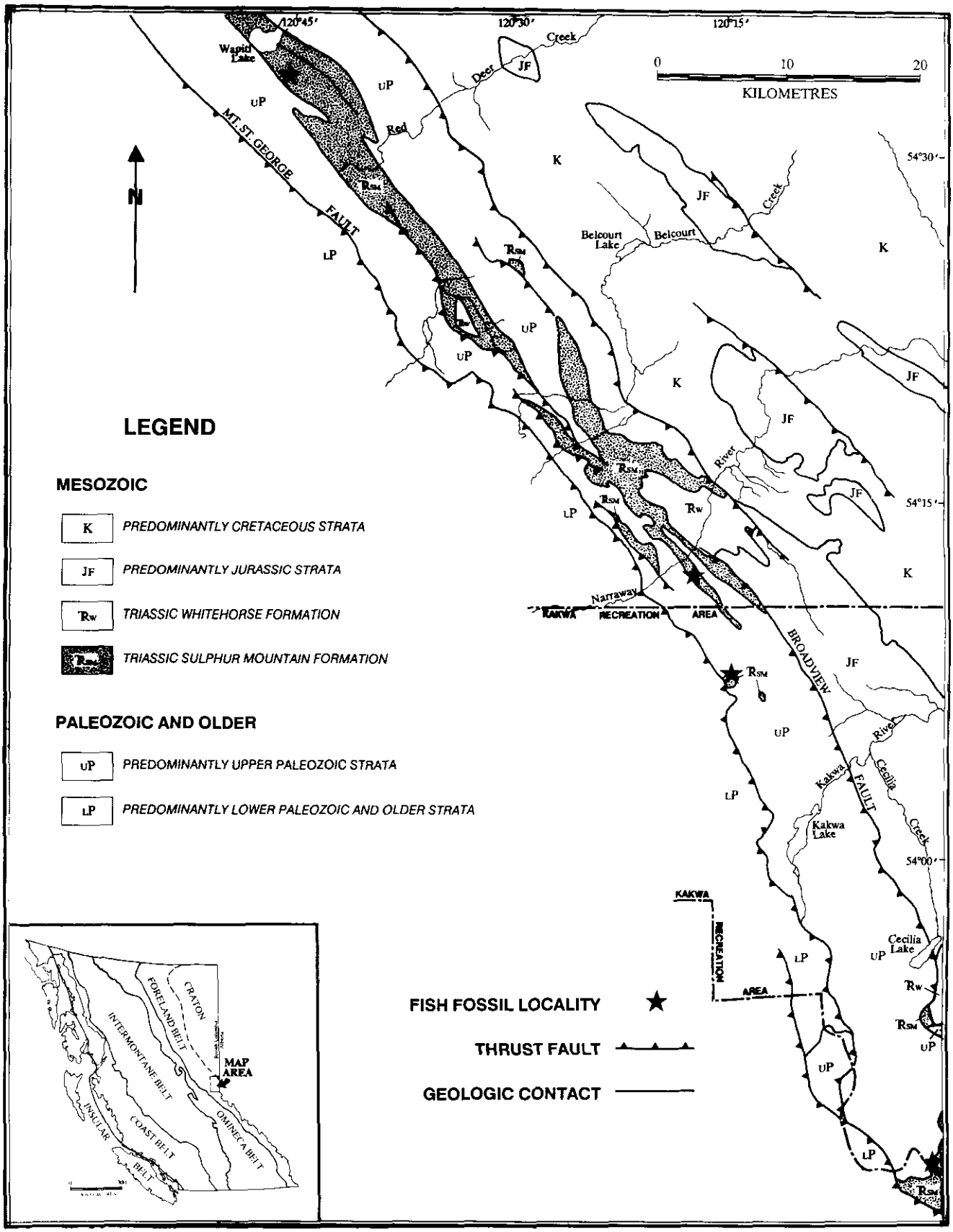

Figure 1-7-1. Distribution of Triassic Sulphur Mountain Formation strata in northeastern British Columbia.

Plate 1-7-1. Ammonite, from the Sulphur Mountain Formation in Kakwa. Such well-preserved specimens are a rarity in this area.

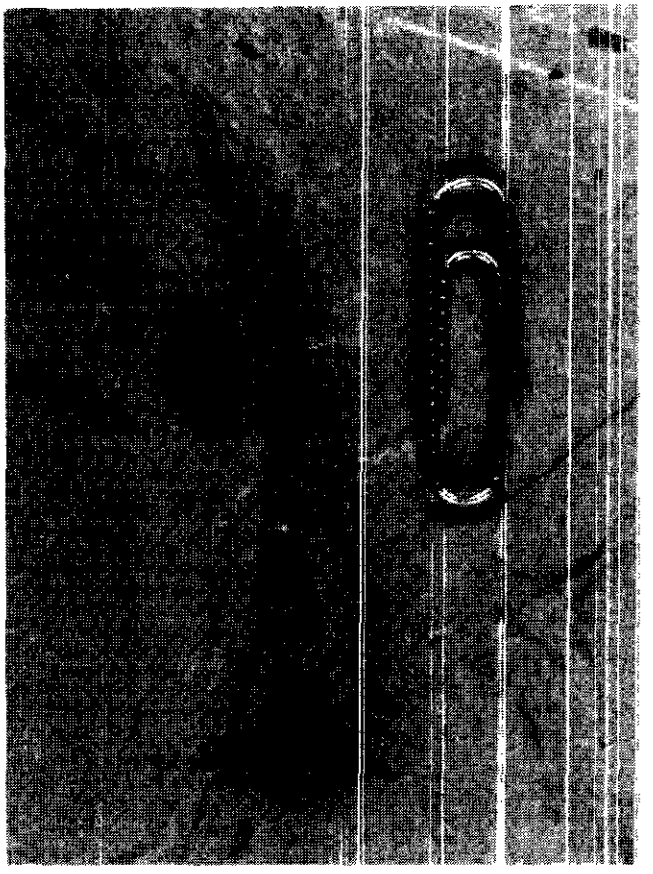

Plate 1-7-2. Chondrichthian spine (cf. *Listracanthus* sp.); such spines are believed to represent some part of the "skin" (shagreen is the correct term) of ancient sharks (paper clip scale is 3 centimetres).

man, personal communication, 1991). Pelecypods were also noted in some sections. Moderately well preserved fish fossils were found at one locality and fragmented fish were found in two other areas (Figure 1-7-1). Fish-bearing strata are estimated to be approximately 30 to 50 metres above the base of the section and probably correlate with similar strata in the Wapiti Lake area, which are Smithian in age (Schaeffer and Mangus, 1976; Tozer, 1967).

The Whistler Member, of Middle Triassic Anisian age, where present, is generally 10 to 20 metres thick and consists of dark grey to black-weathering siltstone, silty limestone, silty shale, dolostone, phosphorite and phosphatic pebble conglomerate (Gibson, 1975). Ammonites, pelecypods and, locally, brachiopods occur in this member and are commonly phosphatic. The Llama Member is characterized by relatively resistant, orange-brown-weathering, thin to thick-bedded dolomitic quartz siltstones, silty limestones and dolostones that contain pelecypods, rare ammonite fossils and, locally, reptile bones. It ranges from Middle Triassic late Anisian to late Ladinian in age. Where it occurs, it is approximately 150 to 185 metres thick.

At the best fossil fish site, only the Vega-Phroso siltstone member is exposed. It overlies light grey quartz arenites of the Mowich Formation that locally form small cliffs at the base of the outcrop, above a talus slope. The upper members are eroded away or truncated by a northeasterly directed thrust fault that is located west of the main outcrop area (Pell *et al.*, 1992, this volume). The base of the exposed section is dark brown to grey-brown-weathering and very fissile to platey; flaggy, buff to orange-weathering calcareous siltstone layers crop out a few tens of metres above the base of the section. The ridge is steep and only the basal beds were examined closely.

Fish fossils were generally found on buff to orange-weathering slabs of calcareous siltstone that varied from 2 to 30 centimetres in thickness, scattered in the talus beneath the outcrop. Fossils were also found on relatively fresh, chocolate to dark grey-brown siltstone slabs. No fossil fish were observed in the basal, fissile shaley beds; it is probable that they are derived from the thicker, flaggy weathering beds higher in the section.

THE FOSSIL FISH

Seven genera of fish, belonging to the Class Osteichthyes (bony fish) have been identified to date, from the Sulphur Mountain Formation in Kakwa Recreation Area (A. Neuman, personal communication, 1991). Since their first appearance in Early Devonian freshwater deposits, there have been two major groups of bony fish: the subclass

Plate 1-7-3. *Bobasatrania canadensis;* complete specimen with distinct vertebral column.
Specimen is 17 centimetres long (paper clip scale is 3 centimetres).

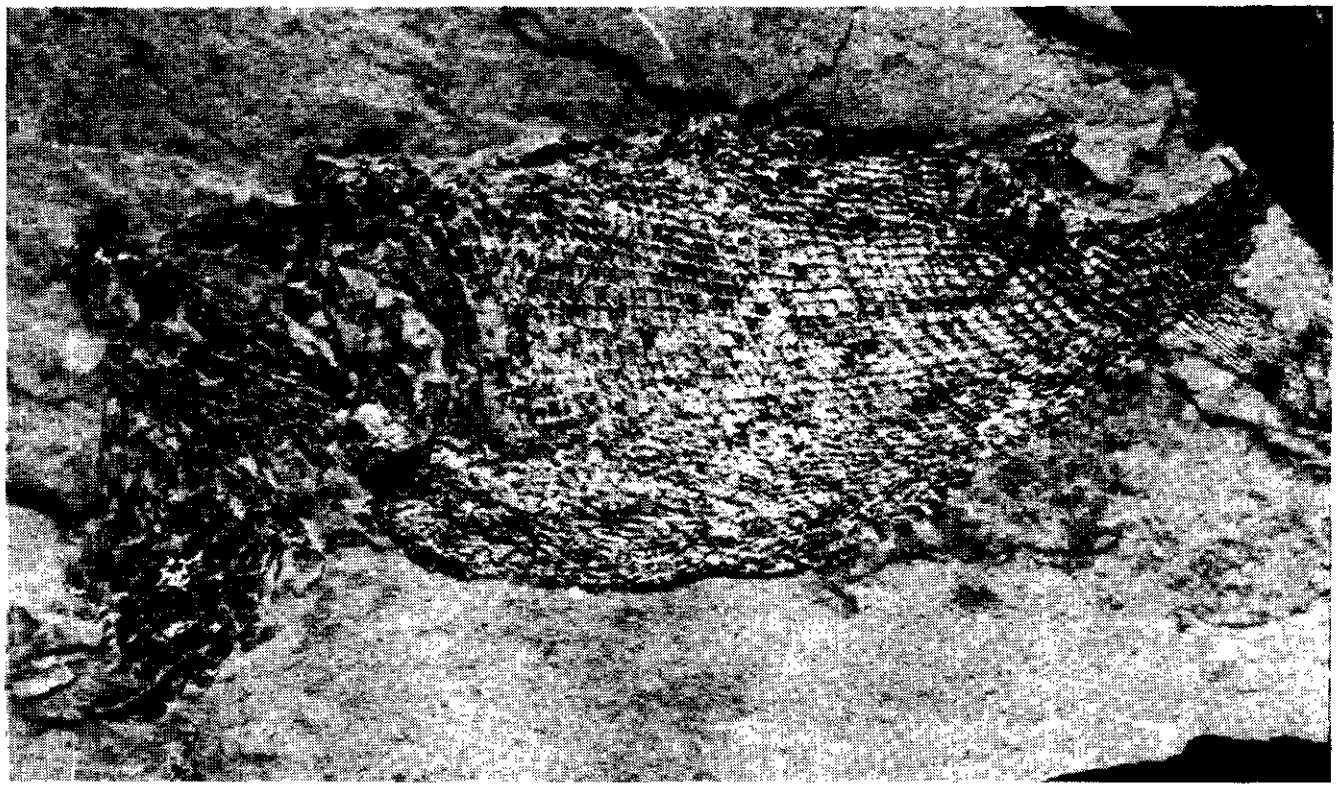

Plate 1-7-4. *Boreosomus* sp.; near-complete specimen; fins, other than caudal (tail) are missing.
Specimen is approximately 25 centimetres long.

Actinopterygii, or ray-finned, and the subclass Sarcopterygii, or fleshy finned (Table 1-7-2). The fin structure is fundamentally different in these two subclasses, as implied by their names. Ray-finned fish have fan-like fins with thin, bony rods for support, like most of the modern fish with which we are familiar, while the fleshy or lobe-finned fishes have stout fins with a strong internal skeleton and muscles (Dodson and Dodson, 1976). Both subclasses are represented in the Triassic deposits from Kakwa.

Ray-finned fish can be further subdivided into infraclasses Chondrostei and Neopterygii (Table 1-7-2). Chondrosteans, or ganoid fish, generally have cartilaginous skeletons, a vertebral column that is upturned at the posterior end and a tail with a heterocercal structure (*i.e.* asymmetrical with a larger upper lobe). They are characterized by the possession of heavy, rhombic, enamel-coated ganoid scales that fit together edge to edge, with very little overlap, and form a heavy, stiff armour. Lungs were present to supplement the gills and jaw muscles were generally small and weak. Many of the more primitive members, such as the Palaeonisciformes, also had well-ossified (bony) skulls. Chondrosteans were common until the end of the Triassic; only a few specialized members of this group, such as the sturgeon (*Acipenser* and *Scaphirhynchus*) and spoonbills (*Polyodon*), have survived to the present (Dodson and Dodson, 1976).

Four genera of ganoid fish (Table 1-7-2) have been identified from the Kakwa area, *Bobasatrania, Boreosomus, Australosomus* and *Saurichthys*. The first two genera are typical or "primitive" chondrosteans, while the latter two are more advanced and sometimes referred to as "subholosteans" (A. Neuman, personal communications 1991). One of the more common genera found at Kakwa was *Bobasatrania;* some of the most distinctive and best-preserved specimens are examples of this genus. *Bobasatrania* has a distinctive "diamond" shape and exhibits many of the typical chondrostean features such as the curved vertebral column with an upturned end and the asymmetrical tail (Plate 1-7-3). Most good specimens are 15 to 20 centimetres in length; however, pieces of individuals that may belong to this genus, measuring up to a metre in size, were found. Members of the other genera were uncommon; only one specimen of *Boreosomus* (Plate 1-7-4) and rare examples of the other taxa were found.

Members of infraclass Neopterygii first appeared in the Permian. One line, the holosteans, became dominant in the Triassic, but by the Cretaceous, had passed their peak and were on the decline toward their present low numbers (there are only two surviving members of this group, *Amia*, the bowfin and *Lepisosteus*, the garpike). The holosteans had more efficient jaw leverage than chondrosteans and had swim-bladders rather than lungs. Their vertebral columns

TABLE 1-7-2
CLASSIFICATION OF FISHES, INCLUDING TAXA FOUND IN KAKWA RECREATION AREA

PHYLUM:	CHORDATA						
SUBPHYLUM:	VERTEBRATA						
Superclass:				PISCES			
Class:	Agntha (Ord. to Perm. & Present) Jawless fish (*lampreys*)	Placodermi (Devonian & Carboniferous) Jawed, armoured *fish*	Chondrichthyes (Devonian to Present) Sharks	Osteichthyes (Dev. to Present) Bony fish			
Subclass:				Actinopterygii Ray-finned fish		Sarcopterygii Fleshy/lobe-finned	
Infraclass:				Chondrostei (E. Devonian >>) Ganoid fish	Neopterygii (Permian >>) Holosteans & Teleosts (Modern fish)	Crossopterygii (E. Devonian >> Rhipidistans & Coelacanths	Dipnoi (E. Dev. >>) Lungfish
Order				Paleonisciformes	Parasemionotiformes	Coelacanthiformes	
Family				Boreosomidae	Parasemionotidae	Coelacanthidae	
Genus:				*Boreosomus*	*Watsonulus*	*Whiteia*	
				Bobasatraniidae	*Albertonia*		
				Bobasatrania			
				Pholidopleuriformes			
				Pholidopleuridae			
				Australosomus			
				Saurichthyiformes			
				Saurichthyidae			
				Saurichthys			

Modified from Dodson and Dodson, 1976 and Andy Neuman, personal communication, 1991.

Plate 1-7-5. *Albertonia cupidinia;* near-complete fish with well-developed pectoral fin and poorly preserved skull. Note distinctive, well-preserved ganoid scales. Specimen is 33 centimetres long (paper clip scale is 3 centimetres).

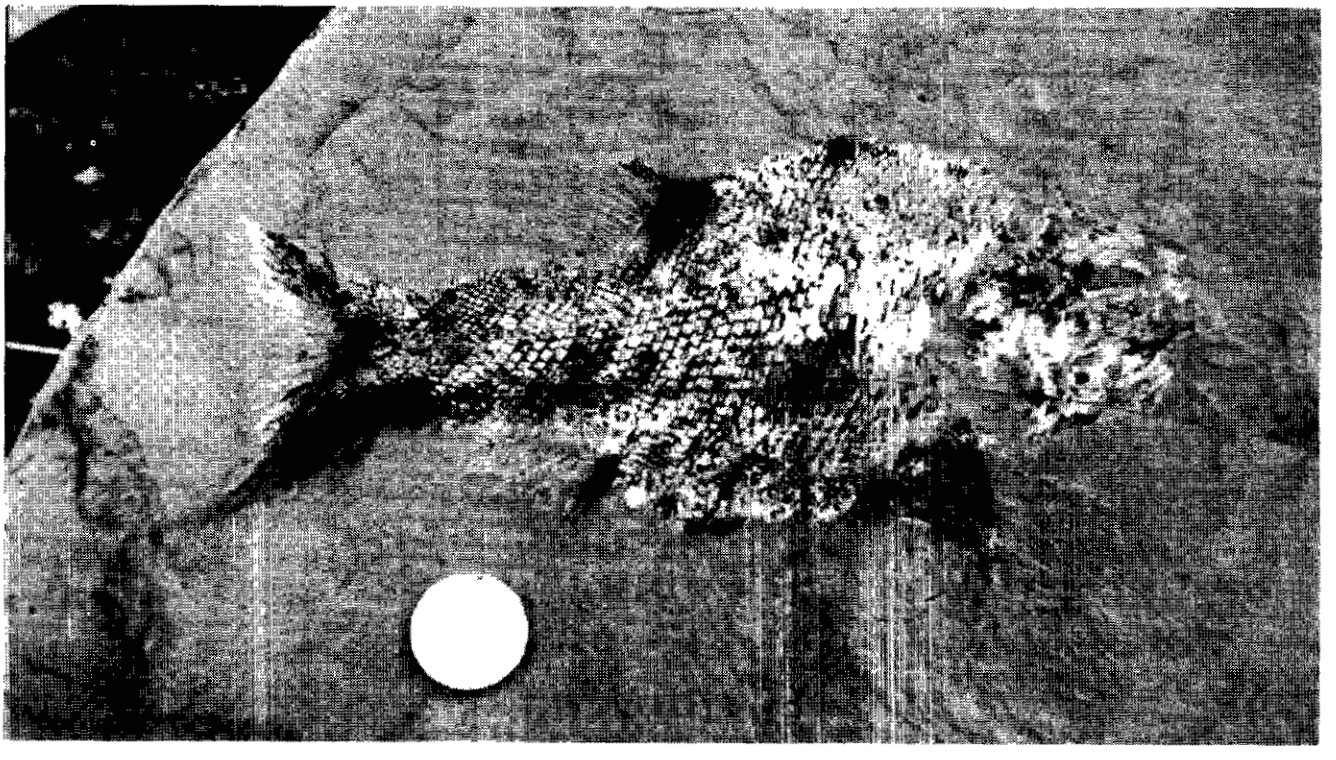

Plate 1-7-6. *Albertonia* sp.; complete fish. Pectoral fin is not as well preserved as in previous specimen. "Loony" for scale is 2.5 centimetres in diameter.

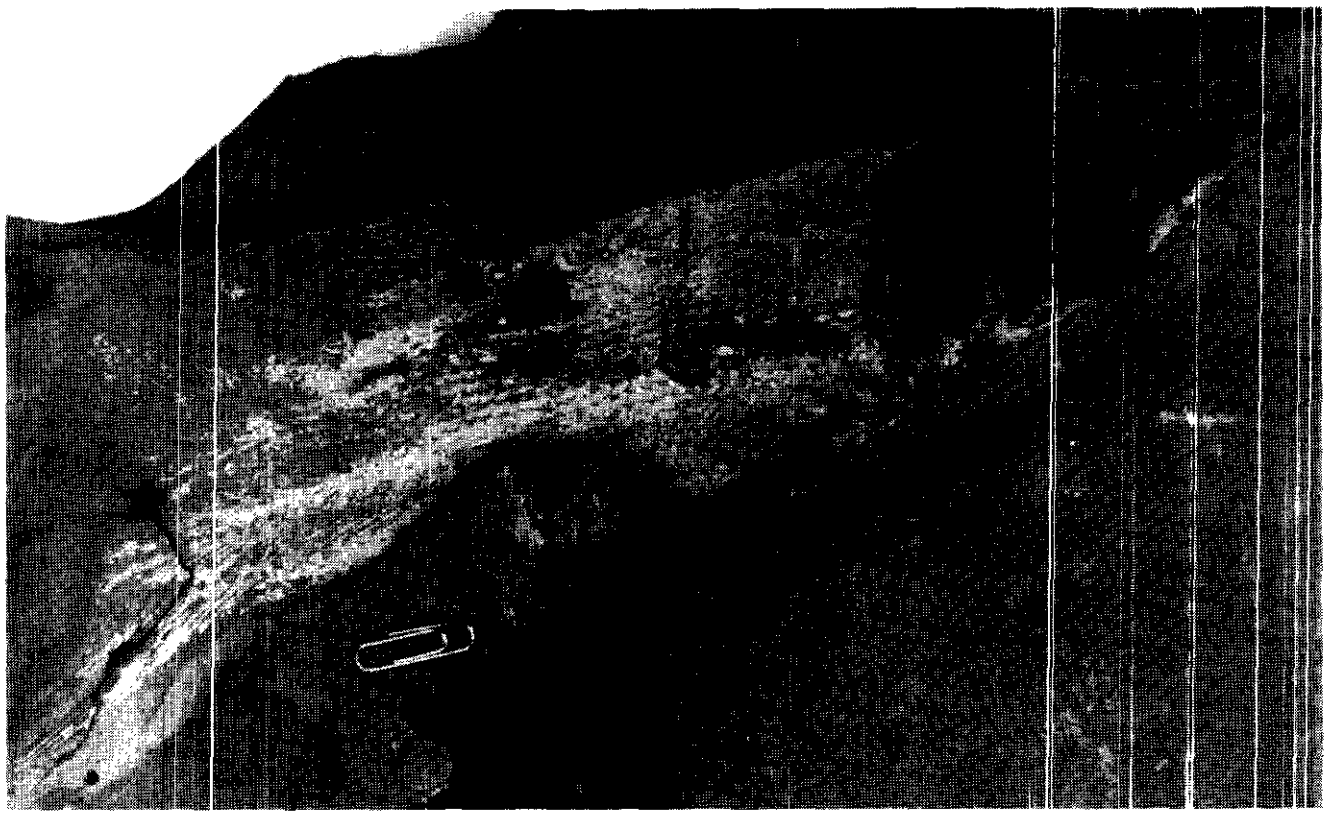

Plate 1-7-7. Coelacanthidae *Whiteia* sp.; near-complete fish, part of caudal (tail) fin missing. Note delicate scale pattern and small, fleshy lobe at base of pelvic fin. Specimen is 35 centimetres long (paper clip scale is 3 centimetres).

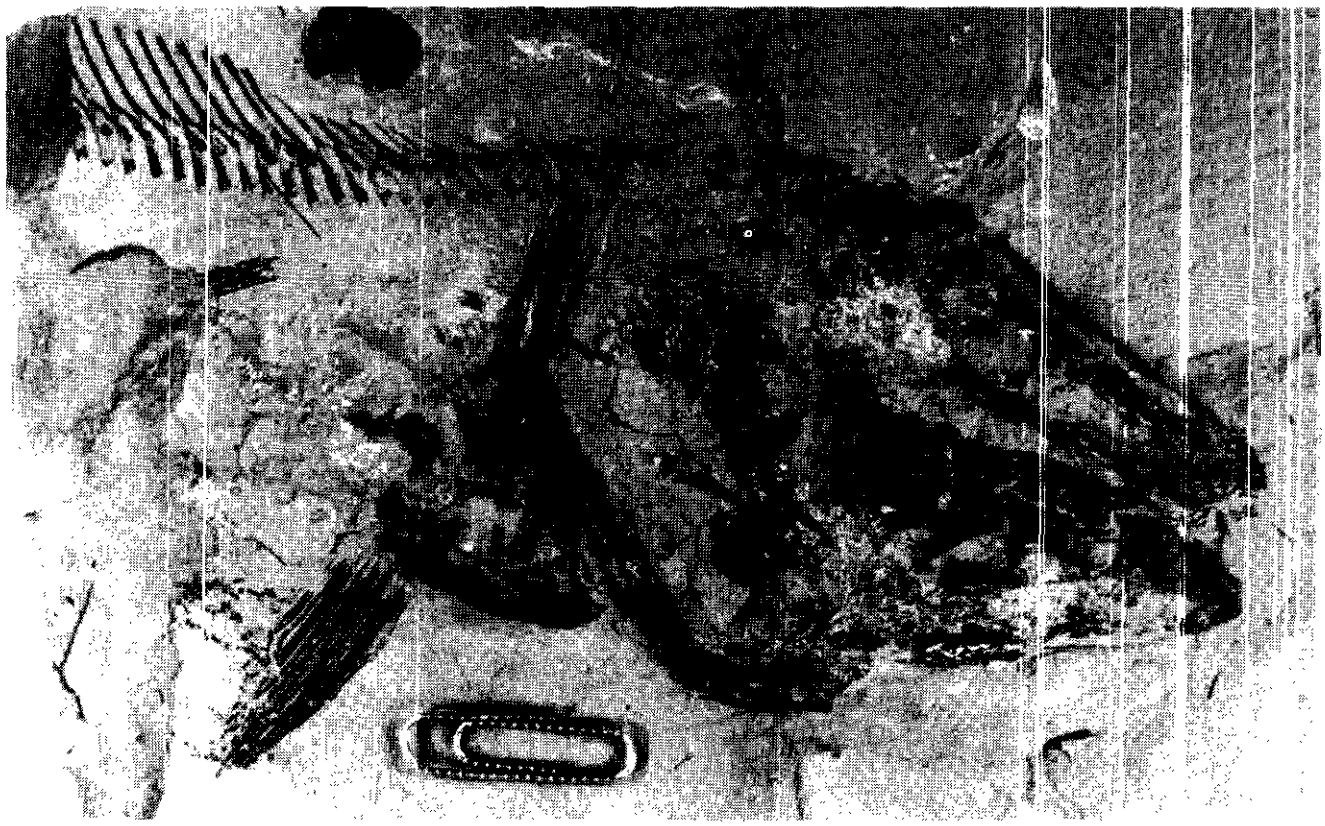

Plate 1-7-8. Coelacanthidae *Whiteia* sp.; skull (paper clip scale is 3 centimetres).

were ossified and, although still slightly upturned at the posterior end, terminated in a more symmetrical tail. Primitive holosteans still retained the ganoid scales, while the more advanced members lost their ganoine covering (Dodson and Dodson, 1976). The other main line, the teleosts, first appeared in the Jurassic, were dominant in the Cretaceous and today comprise more than 95 per cent of the fishes of the world. They are characterized by an entirely bony skeleton, thin, flexible scales that are chips of bone, a versatile jaw mechanism and a symmetrical tail that is conducive to fast swimming.

Two genera of holostean fish, *Albertonia* and *Watsonulus* have been identified from samples collected in the Kakwa area (A. Neuman, personal communication, 1991). Specimens of *Albertonia* are quite abundant; a number of well-preserved individuals were collected. Only one poorly preserved specimen of *Watsonulus* was found. *Albertonia* is one of the largest fish commonly found in the area, individuals measuring 30 to 35 centimetres in length are not uncommon. It has a distinctive form, with a deep body, well-developed ganoid scales, a slightly upturned vertebral column, a large tail and, commonly, elongated pectoral fins (Plates 1-7-5 and 6). It is a unique fish that is fairly easily recognized by the layperson, particularly when the pectoral fins are well preserved.

Lobe-finned fish of subclass Sarcopterygii originated in fresh water in Early Devonian times and from the very beginning comprised two groups, the Dipnoi, or lungfish and the Crossopterygii (Table 1-7-2). Two orders of Crossopterygii exist, the rhipidistians, from which amphibians are believed to have evolved and the coelacanths. From the Devonian to the Permian, coelacanths existed in fresh water; in the Triassic they spread into shallow seas where they persisted until the Cretaceous. They were believed to have been extinct for 75 million years until 1939, when a living coelacanth was caught by a fisherman off the coast of Madagascar. Coelacanths, like other sarcopterygeans, have skull patterns that are completely different from ray-finned fishes and have cosmoid scales, with a dentine-like inner layer rather than the superficial enamel layer present in ganoid scales. Coelacanths generally do not have ossified vertebrae (Dodson and Dodson, 1976).

One genus of coelacanth, *Whiteia,* has been identified from the Triassic deposits in the Kakwa area (A. Neuman, personal communication, 1991). Articulated specimens are between 35 and 75 centimetres long; numerous fragments of coelacanth fossils were also found. *Whiteia* is unique in that the scales, when preserved, are more delicate and less distinct, and tassel-like adornments are common around the tail. The skull structure is different from the actinopterygeans, with the eye socket set farther back. The fleshy nature of the fins can also be discerned in some specimens (Plates 1-7-7 and 8).

CONCLUSIONS

The discovery of well-preserved fish fossils within the Triassic deposits in Kakwa Recreation Area may be significant as there are fewer than 20 areas throughout the world in which similar fossils have been found and only six localities which have yielded more than five genera (Neuman, in press; Schaeffer and Mangus, 1976). Already seven genera from the Class Osteichthyes and one from Chondrichthyes have been identified from Kakwa; more specimens are currently being studied and it is possible that additional taxa will be recognized. It also must be reiterated that specimens were all obtained from a scree slope and that no extensive, systematic sampling effort has yet been made at this site. More work is needed at the Kakwa fossil locality, to accurately identify all taxa present and to locate the stratigraphic position of the fossiliferous horizons; a museum collecting expedition appears to be warranted.

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