important characteristics with the deep sea than does any other shallow-water environment. The most striking are the cold temperature, constant physical environment, low terrestrial sedimentation, and high taxonomic affinities (*2, 6*). Many Antarctic species also have depth distributions into at least bathyl environments (*18*). An obvious dissimilarity between the Antarctic benthos and the deep sea is the seasonal productivity of the Antarctic. This seasonal plankton bloom is much reduced along the West Sound, where the relatively high diversity, low standing crop, and the parallel epifaunal patterns make these sites similar to bathyl deep-sea communities. To be sure, there are differences between the West Sound and the abyssal deep sea, which has much lower densities; furthermore, in the bathyl deep-sea habitats the individual animals are smaller than those from the West Sound. But relative to any other shallow area in the world, the West Sound is remarkably similar to deep-sea habitats. Animals have been collected previously from under the shelf ice at McMurdo Sound (*19*), and four fish were trapped below the shelf ice in King George Sound (*20*); but this report presents what we believe to be the first quantitative description of benthic life likely to be found under at least the northern part of the Ross Ice Shelf. In addition, the deep-sea parallels are exciting because the West Sound sites are within diving depths, making possible important natural history observations regarding such questions as microhabitat differentiation, dispersal patterns, various developmental and growth rates, megafaunal behavior patterns, and so forth. Most important, it allows experimental tests of alternate hypotheses (*21*) regarding mechanisms organizing the deep-sea and other benthic communities.

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23. Screen size was 0.5 mm. Other Vermes were primarily *Phoronopsis viridis*. J. W. Nybakken (personal communication) found a dense (more than 240,000 per square meter) transient aggregation of the amphipod *Corophidium unei* in the intertidal Elkhorn Slough.
24. Data are from E. L. Mills [*J. Fish. Res. Board Can.* **24**, 305 (1967)], who apparently picked animals from unscreened sediment. Amphipods were primarily *Ampelisca abdita*, and mollusks, *Gema gema*. H. L. Sanders, E. M. Goudsmitt, E. L. Mills, and G. R. Hampson [*Limnol. Oceanogr.* **7**, 63 (1962)] found more than 330,000 *G. gema* and 115,000 ostracods per square meter from the same locale; these were very small individuals from unscreened, completely sorted samples.
25. Supported by the Office of Polar Programs, National Science Foundation. We thank the officers and crew of the *Burton Island* for their support and J. W. Nybakken and Moss Landing Marine Laboratory for lending us their Smith-McIntyre grab. We are grateful for logistic support by the U.S. Navy, U.S. Coast Guard, and Holmes and Narver, contractors for the National Science Foundation. G. A. Robilliard, J. D. Rude, D. Watson, and E. O'Connor were members of our team and contributed many dives and countless hours of support in the field. P. N. Slattery, J. Boland, J. Monocal, and G. Gillingham helped sort the samples. We thank J. H. Dearborn for his taxonomic assistance and encouragement; L. B. Dayton, D. Rivera, and D. M. Oliver, for tolerance and editorial assistance; and R. R. Hessler and W. A. Newman, for their help and for reviewing the manuscript. We mourn the loss of our companion, J. D. Rude, who died in McMurdo Sound, 12 October 1975, when his vehicle fell through the ice.

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Netschaëvo: A New Class of Chondritic Meteorite

Abstract. *The ratios of refractory elements to silicon and of zinc to silicon indicate that the silicate portion of the Netschaëvo meteorite is an ordinary chondrite. The scarcity of chondrules, the large dimensions (about 100 micrometers) of plagioclase grains, and the low indium content (0.09 nanogram per gram) indicate that Netschaëvo belongs to petrologic type 6. On a diagram of reduced iron versus oxidized iron, Netschaëvo lies along an extrapolation of the LL-L-H ordinary chondrite fractionation trend. The abundances of siderophile elements (nickel, germanium, iridium, and gold) are about 1.6 to 2.0 times greater than in H-group chondrites, and siderophile/nickel ratios are, with one exception, those expected from LL-L-H trends. This evidence indicates that Netschaëvo is an extremely iron-rich member of the ordinary chondrite sequence, and that plausible models to account for the ordinary chondrite sequence must produce materials having iron/silicon ratios 25 percent greater than those in CI carbonaceous chondrites. The existence of Netschaëvo emphasizes that the chondritic meteorites in terrestrial collections are a biased and incomplete selection of primitive solar system materials.*

The Netschaëvo meteorite consists of angular silicate masses set in a metallic matrix; Buchwald (*1*) estimated the amount of silicate material to be 25 percent by volume. Figure 1 shows a silicate-rich portion of the meteorite.

Olsen and Jarosewich (*2*) investigated the major-element mineralogy, petrography, and composition of the Netschaëvo silicate materials, confirmed the presence of chondrules (*3*), and concluded that the properties of this meteorite were intermediate between those of E-group (enstatite) and H-group ordinary chondrites. We find that their evidence shows that the relationship to the ordinary chondrites is much closer than to the E-group chondrites; they in fact noted that Netschaëvo's high total Fe/Si ratio makes it "more H" than the H (for high-Fe) chondrites.

In an attempt to clarify the relationship of the silicate portion of Netschaëvo to the ordinary chondrites, we determined by radiochemical and instrumental neutron activation analysis (RNAA and INAA) a total of 26 elements in duplicate samples (Table 1). We also report data on the metallic matrix "iron meteorite" portion of Netschaëvo including Ni determined by atomic absorption spectrometry; Ga, Ge, and Ir by RNAA;

and Co, As, W, Re, and Au by INAA (Table 2). The details of our techniques are given elsewhere (4, 5). There is good agreement between our data and those of Olsen and Jarosewich (2) for elements mutually determined.

The abundances (that is, the element/Si atom ratios) of refractory lithophiles (Mg, Al, and Ca) and moderately volatile elements (Zn) in chondritic meteorites are illustrated in Fig. 2; refractory element data are mainly from Olsen and Jarosewich (2); CM, CO and E data are from Michaelis *et al.* (6); and Zn data are from our research group. It is well known that refractory abundances are "quantized" within each group and that there is a systematic decrease through the chondrite sequence carbonaceous-ordinary-enstatite. The abundances of Mg and Al in Netschaëvo are clearly in the range of ordinary chondrites; the Ca abundance is outside the "normal" range, but two L-group analyses by Olsen and Jarosewich are equally discrepant, and the value is well below the range observed in CM and CO carbonaceous chondrites. Our data show that Zn also tends to be quantized in chondrite groups other than the E group. The Netschaëvo Zn value is about 1.6 standard deviations lower than the ordinary chondrite mean but within the observed H-group range. Thus the silicate fraction of Netschaëvo is closely related to the ordinary chondrites.

Van Schmus and Wood (7) assigned the chondrites to six petrologic types based on the degree of equilibration and recrystallization observed in their constituent minerals; an increasing type number corresponds to an increasing degree of recrystallization. Concentrations of volatile elements are also useful indicators of the petrologic type of ordinary chondrites (8). The rarity of resolvable chondrules (Fig. 1), the large size (~ 100 μm) of the plagioclase grains, and the low In concentration (0.09 ng/g) indicate that Netschaëvo is petrologic type 6.

Siderophile abundances (relative to Ni) of the chondritic and iron-meteorite portions of Netschaëvo are remarkably similar (Fig. 3). This similarity may have resulted from diffusive equilibration. We tend to discount this possibility because siderophiles in the metal and the chondritic silicates in the Campo del Cielo iron have not equilibrated although the system has been hot enough to produce partial melting in the silicates (5). If equilibration occurred in Netschaëvo, the bulk composition of the host metal should not have changed appreciably since it is ten times more abundant than the chondritic metal. We show below that the metal composition is approximately that expected of an ordinary chondrite more metal-rich than the H chondrites; this finding suggests that the metallic and chondritic portions of Netschaëvo formed in the same portion of the nebula, and that the silicate-free metal formed by a mechanism which did not significantly alter its composition (9).

The LL-, L-, and H-group ordinary chondrites have nearly identical abundances of refractory and moderately volatile elements (10, 11), but they differ in their Fe abundance (Fe/Si atom ratio)

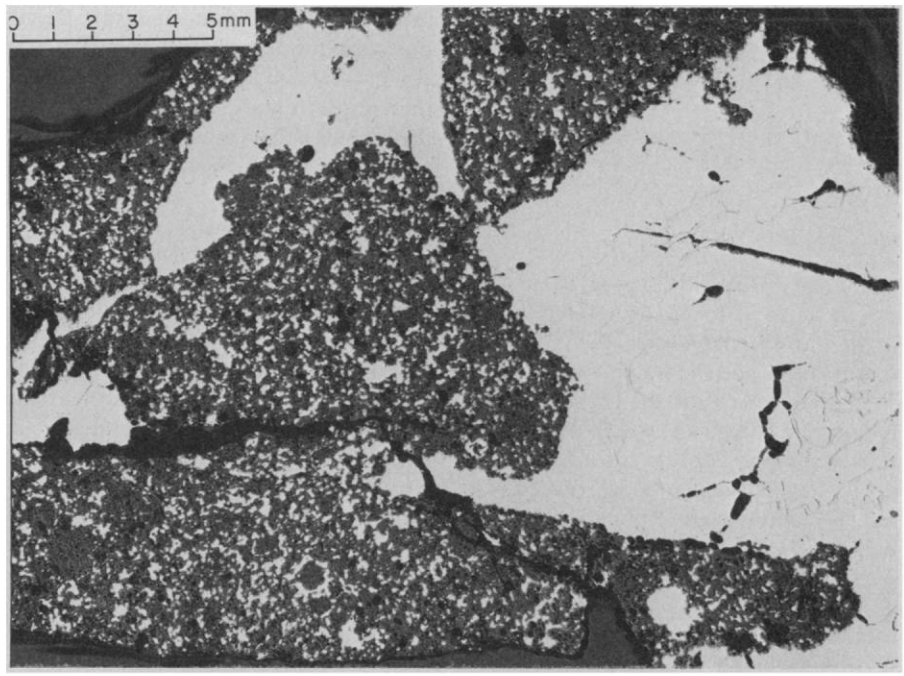


Fig. 1. In the Netschaëvo meteorite angular, metal-rich chondritic silicates are enclosed in a metallic matrix (the metal is light in this photo made with reflected light). The metal in the silicate portion is uniformly distributed, consistent with its incorporation during nebular agglomeration processes; there is no veining, as would be expected if the high metal content resulted from shock-produced transport. There are two prominent chondrules in the lower left corner. [Photo by V. F. Buchwald]

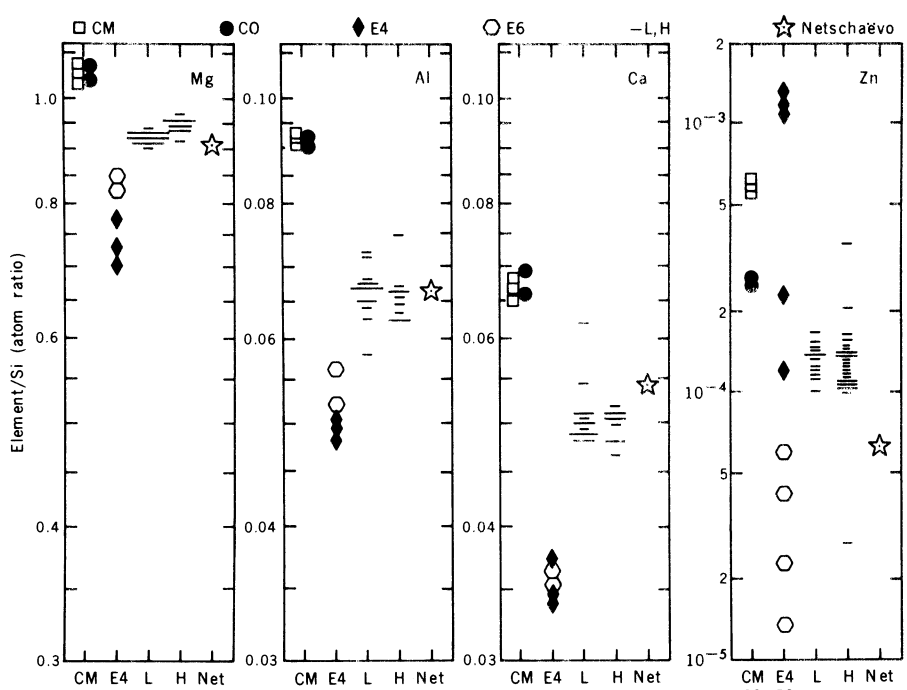


Fig. 2. Comparison of the abundances of three refractory elements (Mg, Al, and Ca) and (on a reduced scale) one moderately volatile element (Zn) in Netschaëvo with those in carbonaceous, enstatite, and ordinary chondrites. In each case the Netschaëvo datum is within the range observed in the ordinary chondrites and, with the exception of Zn in E6 chondrites, outside the range observed in the other groups.

Table 1. Mean concentrations of 26 elements in the silicate portion of Netschaëvo determined by INAA and RNAA. Error limits not shown are estimated to be < 10 percent.

Element (mg/g)	Element (μg/g)	Element (ng/g)
Al 8.5	Ga 13.4	Au 410 ± 41
Ca 9.0	Ge 26.3 ± 1.1	Cd 20
Co 1.72	K 620 ± 80	In 0.09 ± 0.01
Cr 3.30	Ru 3.4 ± 0.7	Ir 1610 ± 160
Fe 410	Sc 7.0	La 200 ± 20
Mg 122	Ti 300 ± 200	Sm 160
Mn 1.78	V 51	Eu 110 ± 28
Na 5.20	Zn 22.1	Yb 210 ± 34
Ni 33 ± 2		Lu 25 ± 5

and in the distribution of oxidized and reduced forms of Fe. As illustrated in Fig. 4, in the LL chondrites the Fe abundance is low and the fraction of oxidized Fe is high, whereas in the H group the Fe abundance is high and the oxidized fraction is low; the L group has intermediate properties. Although most researchers have accepted the interpretation of Urey and Craig (*12*) that the variation in the degree of Fe oxidation within each group is superimposed on a fixed Fe/Si ratio, Müller *et al.* (*13*) suggested that the evidence was better understood in terms of a model in which each group was considered to be a small segment of a continuous fractionation sequence (dashed line, Fig. 4). Dodd (*14*) noted a correlation between the degree of fractionation and the petrologic type.

Wasson (*15*) proposed that the continuous fractionation sequence might result from the following mechanism. During the period when the solar nebula was cooling and condensation was occurring, the entire ordinary chondrite portion of the nebula behaved as a closed system; condensation of Fe began earlier at the H location and last at the LL location; solids remained fixed at the location where they condensed, but gases continued to interchange throughout the system; as a result, the relative amount of siderophiles decreased through the sequence H-L-LL and the decrease was greatest for refractory siderophiles and least for moderately volatile siderophiles. One piece of evidence in conflict with this model was the fact that the mean Fe/Si ratio in the three groups is about 0.65 to 0.70, much lower than the values of 0.85 in CM or 0.90 in CI chondrites that are normally taken to represent mean solar system matter. If the model were correct, ordinary chondrites having higher total Fe/Si ratios and a greater fraction of the Fe in reduced phases should exist in space and occasionally fall as meteorites.

Table 2. Mean concentrations of siderophilic elements in the metallic portion of Netschaëvo.

Element	Element
Co 4.3 mg/g	W 1.2 μg/g
Ni 86 mg/g	Re 0.32 μg/g
Ga 24.8 μg/g	Ir* 1.8, 3.9 μg/g
Ge 66 μg/g	Au 1.3 μg/g
As 11.6 μg/g	

*The first Ir value from Scott and Wasson (*20*); the second is an unpublished datum of E. R. D. Scott determined on an independent specimen.

The Fe/Si ratio (1.10) in Netschaëvo is appreciably greater than that in H, CI, or CM chondrites (Fig. 4). Although Wiik's (*16*) analysis of H-group Rose City shows a comparable Fe/Si ratio, Rose City is highly shocked with much of the metal now present in veins, and it seems probable that Wiik's sample was not representative. Furthermore, the olivine in Rose City is Fa_{19} (19 mole percent fayalite) (*17*), a typical H-group value, substantially greater than the Fa_{14} value in Netschaëvo (*2*). In contrast to Rose City, there is no evidence for a signifi-

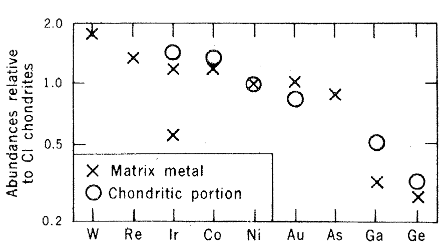
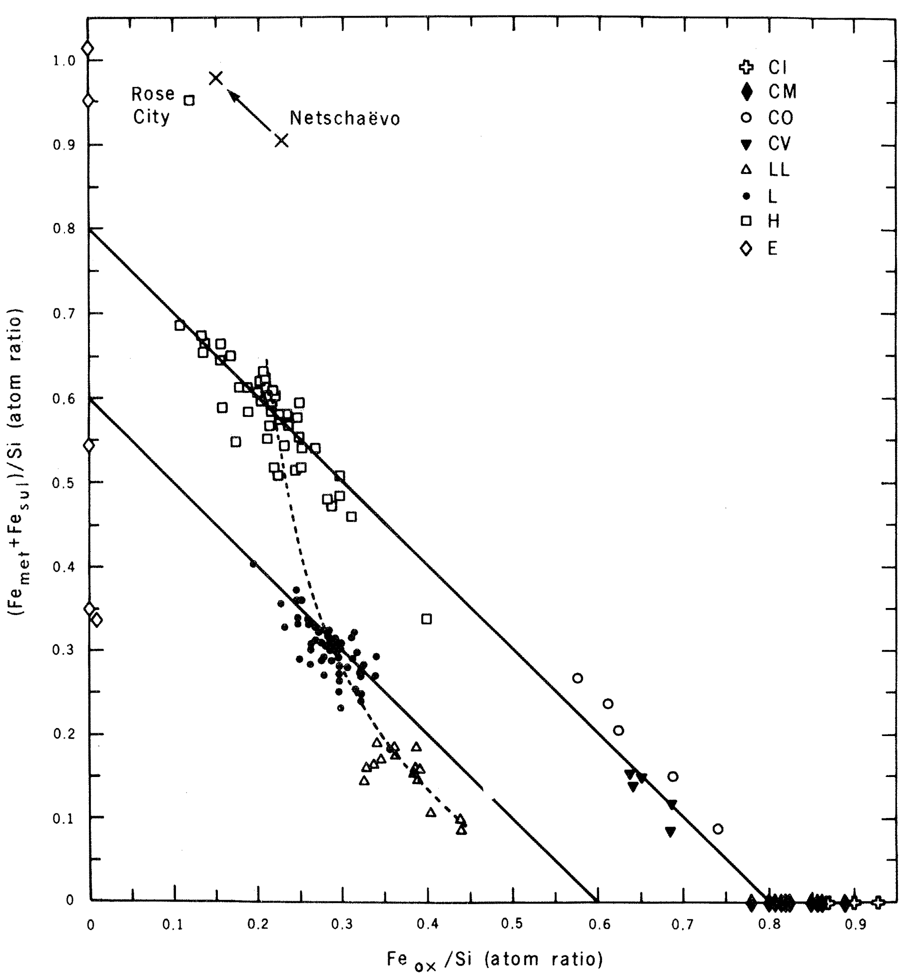


Fig. 3 (above). The CI-chondrite normalized siderophile/Ni ratios in the Netschaëvo "chondrite" and "iron meteorite" portions show very good agreement. If one ignores the low Ir content found in one metal sample, the only one element showing a significant discrepancy is Ga: its enrichment in the chondritic portion reflects its tendency to be found in silicates as well as metal. Fig. 4 (right). Distribution of Fe between "reduced" metal and troilite phases and the more oxidized phases of chondritic meteorites. The dashed curve through the ordinary chondrite H, L, and LL groups represents a possible nebula fractionation trend. Netschaëvo falls along an extension of this curve and appears to be an ordinary chondrite with a higher Fe/Si ratio and lower degree of oxidation than the H-group chondrites. The lower Netschaëvo point is calculated from the data of Olsen and Jarosewich (*2*); the upper value shows that datum corrected to correspond to the actual Fe/Si ratio determined by electron microprobe in the oxidized phases.



cant redistribution of metal in Netschaëvo (Fig. 1). It is therefore of interest to investigate whether there is other evidence that Netschaëvo fits into the proposed fractionation sequence of ordinary chondrites.

Müller *et al.* (*13*) observed a fractionation of Ir from Ni through the ordinary chondrite sequence, with Ir/Ni ratios distinctly higher in the H group than in the L group. Recent unpublished data from our research group show that the Au/Ni ratio is about the same in the H and L groups, whereas the Ge/Ni ratio is lower in the H than in the L group. Figure 5 shows the relationship of Netschaëvo to H- and L-group chondrites in terms of the ratios of these four siderophiles to Si. Netschaëvo follows the ordinary chondrite trend on the Ir/Ni and Au/Ni diagrams to within experimental error (Fig. 5, a and c); its Ge/Ni ratio, however, is higher than observed in the H group, and about 10 to 20 percent higher than that expected from the trend of the L and H groups (Fig. 5b). Since the error in the Ge/Ni ratio should be only about ± 10 percent, this datum seems to be inconsistent with the interpretation that Netschaëvo is part of the ordinary chondrite fractionation sequence.

Siderophile/Si ratios in Netschaëvo are about 1.6 to 2.0 times greater than those in the most Fe-rich H-group chondrites (Fig. 5). Although this is a surprisingly large factor, the range between LL and H chondrites is still larger. We have not included LL chondrites in our diagram but unpublished data show that their siderophile contents are about the same as those shown for Barratta, the lowest L-group point in Fig. 5, and that the siderophile fractionation factors across the ordinary chondrite sequence are in the range 2.5 to 3.3.

In summary, the classification of the silicate portion of Netschaëvo as an ordinary chondrite is indicated by its abundance of refractory lithophiles, Mg, Al, and Ca; the Zn abundance is 1.6 standard deviations lower than typical of ordinary chondrites but within the observed range, and lower than the values found in chondrite groups other than E6. The abundances of Fe and siderophile elements, the Ir/Ni and Au/Ni ratios, and the Fe content of the ferromagnesian minerals indicate that Netschaëvo lies along an extension of the ordinary chondrite fractionation sequence to higher Fe/Si ratios. Although the Ge/Ni ratio in Netschaëvo is about 15 percent higher than expected from the trend through the ordinary chondrite sequence, this minor inconsistency can be neglected in light of the other evidence that Netschaëvo follows the ordinary chondrite siderophile and oxidation-state fractionation trends. Thus, the weight of evidence supports the hypothesis that Netschaëvo is the first member of a new group of ordinary chondrites with properties predictable from an extrapolation of trends observed in the LL-L-H sequence (*18*).

The addition of Netschaëvo to the ordinary chondrite fractionation sequence supports the contention of Tandon and Wasson (*19*) and Müller *et al.* (*13*) that the three ordinary chondrite groups are part of a continuous fractionation sequence incompletely sampled by the earth. It is consistent with the siderophile-lithophile fractionation model proposed by Wasson (*15*) and inconsistent with models that call for metal loss but not gain from a starting mixture near the cosmic Fe/Si ratio (*10*).

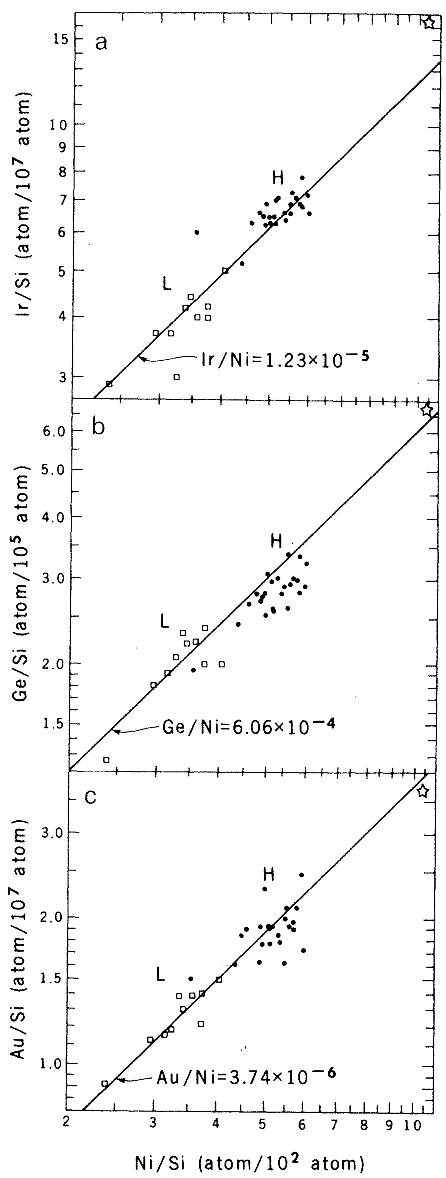


Fig. 5. Plots of (a) Ir/Si, (b) Ge/Si, and (c) Au/Si versus Ni/Si in H- and L-group chondrites and in Netschaëvo silicates. Lines with unit slopes representing constant siderophile/Ni ratios are drawn roughly through the centroids of the H and L data. The star representing Netschaëvo lies slightly above the Ir/Ni (a) and slightly below the Au/Ni (c) lines, consistent with the observed increase in Ir/Ni and decrease in Au/Ni between the L- and H-groups. The Ge/Ni ratio (b) is about 10 to 20 percent higher than the expected value, slightly lower than the line.

The extension of the ordinary-chondrite fractionation trend shows that the primitive solar system materials in terrestrial meteorite collections represent only an incomplete selection of the range present early in solar system history. Although modern methods allow ~ 98 percent of all chondritic materials to be classified into ten well-defined groups separated from each other by hiatus in a number of chemical or petrographic parameters, there is good reason to believe that the variations in these parameters were continuous and that the well-defined classes arise because most meteorites come from a limited number of parent bodies. In some cases the properties of these missing meteorite groups can be inferred from trends observed among the abundant groups, but confirmation is possible only by the investigation of rare types of chondritic materials such as Netschaëvo.

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Crocodile with Laterally Compressed Snout: First Find in Australia

Abstract. *A crocodilian skull exhibiting a high, laterally compressed snout has been found in a cave in north Queensland. No teeth are preserved, but elliptical alveoli suggest a ziphodont dentition. This is the first known occurrence of such a crocodilian in Australia and probably the most recent in the world. The specimen is not referable to any known species.*

During the exploration of caves near Chillagoe, north Queensland, in 1970, Lyndsey Hawkins of the Sydney University Speleological Society discovered an incomplete crocodilian skull of unusual form. The specimen (Australian Museum F.57844) comprises the snout from the anterior margins of the orbits to just behind the anterior margin of the external nares. Unlike living crocodilians, in which the snout is usually low, the snout of this specimen is high with sides that are nearly vertical. The form of the alveoli suggests that the teeth were ziphodont (laterally compressed); however, no teeth have been preserved in the specimen. Such a snout form is associated with ziphodont teeth in both the sebecosuchian and pristichampsine crocodilians, neither of which has previously been reported from Australia.

The snout was found lying upside down on the floor of Tea Tree Cave about 200 feet from the entrance. Both Recent (*1*) and Pleistocene mammalian remains have been reported from caves in the Chillagoe area, those from Tea Tree Cave being considered Pleistocene (*2*). Local fissure fills, possibly contemporaneous with the cave deposits, yield forms believed to be late Pleistocene (*3*). While AM F.57844 cannot have been derived from the Paleozoic rock through which the caves have formed (*4*), it is not clear that it in fact derives from the cave deposits: it seems unlikely, however, that a specimen of greater than Pleistocene age would have been found lying on the cave floor. No ziphodont crocodilians from outside Australasia have been recorded from rocks younger than Miocene. As this is likely to be the most recent occurrence of such a crocodilian, as well as the first report from Australia, it is appropriate to present this brief description.

The general aspect of the specimen is shown in Fig. 1; thus, only features of special interest will be described. Twelve alveoli are represented in the left maxilla and, although it is incomplete posteriorly, the marked narrowing of the maxilla indicates that there is little if any space for another alveolus. The elliptical form of the alveoli, longer anteroposteriorly than wide, suggests that ziphodont teeth were present. Some justification for this assumption is provided by the skull of *Brachychampsa montana* in which the cross-sectional form of the rounded anterior and the elliptical posterior maxillary teeth is closely reflected in the form of their respective alveoli (*5*). Pleistocene ziphodont crocodilian teeth found in north Queensland (*6*) exactly fit the alveoli of AM F.57844, but were not associated with this specimen. The first to fifth maxillary alveoli are all nearly equal in size, as are the somewhat smaller sixth to tenth.

Distinct alveolar processes are present on the maxillae and premaxillae, and shallow fossae medial to these accommodated the dentary teeth. A marked notch at the premaxillary-maxillary junction presumably received an enlarged fourth dentary tooth.

The palatal portion of the maxilla indicates that the anterior process of the palatine was short, extending no more than 1 cm in front of the anterior end of the palatal fenestra. That fenestra extends well forward of the back of the tooth row. The foramen incisivum and, probably, the external nares were wider transversely than long. The palatal portion of the maxillary-premaxillary suture is V shaped with the apex directed posteriorly.

The external nares are large, confluent, with a raised rim. Lateral festooning of the maxilla is absent. The nasals are restricted to the dorsal surface of the snout and have parallel sides centrally, tapering both anteriorly and posteriorly. The external sculpture consists of shallow pits and ridges, marked toward the nares, with well-developed ridges along the anterodorsal margins of the orbits. Medially adjacent to these ridges shallow sulci extend anteriorly, parallel to the nasal-maxillary union, almost to the external nares.

The high, laterally compressed snout invites comparison with sebecosuchians, pristichampsines, and certain living crocodylids. Comparison will be made with these forms in that order. Unfortunately, the most obvious distinguishing characters occur in the posterior portion of the palate, which is lacking in AM F.57844. Of the sebecosuchians other than *Sebecus* (*7, 8*) most are too incomplete for comparison, while others (for example, *Baurusuchus* and *Bergisuchus*) are obviously different from AM F.57844 in snout form and dentition. Of the pristichampsines, *Pristichampsus rollinati* (*9*), *Pristichampsus vorax* (*10*), and *Planicrania datangensis* (*11*) are sufficiently well preserved for comparison. Sebecosuchians differ from pristichampsines in the width of the snout relative to its length, the median crest of the nasals and their overall form, the posterior process of the premaxilla, the placement of the anterior margin of the palatal fenestrae relative to the back of the tooth row, and the number of teeth (*7, 9*). These latter two characters are different in sebecosuchians from all eusuchians.

In *Sebecus* (and *Bergisuchus*) the snout is narrow, while in *Pristichampsus* it is described as of intermediate width (*10*). The snout of AM F.57844 is wider relative to its length than that of *Pristichampsus*.

The nasals of *Sebecus* form a crest along the top of the snout (*8*) and hence are obvious in lateral view, while in pristichampsines they are restricted to the dorsal surface of the snout (*10*) as they are in AM F.57844. From above, the nasals of *Sebecus* taper slightly toward the front and flare out posteriorly, while those of pristichampsines and AM F.57844 taper both anteriorly and posteriorly.

The shorter posterior process from the upper portion of the premaxilla is present both in AM F.57844 and pristichampsines (and indeed in eusuchians in general) but lacking in *Sebecus*. The palatal fe-